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BTeV Project Management System Description

Rev. 3

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BTeV

Project Management System Description

BTeV Document

November 2004

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BTeV Project Management System Description
Change Log

Revision No.	Pages Affected	Effective Date
Revision 0	Entire document	July 2004
Revision 1	Entire document	September 2004
Revision 2	Entire document	October 2004
Revision 3	Appendix C + overhead and accrual corrections	November 2004

BTeV PROJECT MANAGEMENT SYSTEM DESCRIPTION
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1.

ACRONYM LIST

ACWP	Actual Cost of Work Performed
BA	Budget Authority
BAC	Budget at Completion
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
BTeV	B physics at the Tevatron experiment
CCB	Change Control Board
CD-1	DOE Critical Decision 1: Approve Alternative Selection and Cost Range
CD-2	DOE Critical Decision 2: Approve Performance Baselines
CPR	Cost Performance Report
DOE	U.S. Department of Energy
DOE-FSO	Department of Energy Fermilab Site Office
EAC	Estimate at Completion
ETC	Estimate to Complete
EV	Earned Value
EVM	Earned Value Management
EVMS	Earned Value Management System
FNAL	Fermi National Accelerator Laboratory
HQ	DOE Headquarters
FWP	Field Work Proposal
LOE	Level of Effort
MIE	Major Item of Equipment
M&S	Materials & Services
OP	Welcom Open Plan® project planning software
PCR	Project Change Request
PEP	Project Execution Plan (BTeV Document)
PMB	Performance Measurement Baseline
PMP	Project Management Plan(BTeV Document #)
QA	Quality Assurance
QAP	Quality Assurance/Procurement
QC	Quality Control
RFP	Request for Proposal
RFQ	Request for Quote
RMB	Risk Management Board, a subset of the BTeV Technical Board
TB	Technical Board
TCSSA	Technical, Cost, Schedule, Safety Assessment Form
TEC	Total Estimated Cost

WBS Work Breakdown Structure

1. INTRODUCTION

1.1 PURPOSE

This document describes the project management system implemented within the Fermi National Accelerator Laboratory (FNAL) to execute the BTeV project successfully. The project management system is a closed-loop system, whose purpose is to plan, monitor, manage, control, and report on project execution. It is the policy of the BTeV Project Director that all BTeV project personnel comply with the requirements of the systems described within this document and use them in planning, managing, executing, monitoring, and reporting work.

The purpose of the BTeV Project is to design, construct, and install the BTeV detector, interaction region, and supporting experimental facilities needed to achieve the physics goals set out in the BTeV Proposal Update of April 2002. Beginning in CY 1998, an effort has been underway to carry out conceptual design activities and R&D to be able to construct this detector. This has resulted in a detailed technical design, described in the BTeV Detector Technical Design Report. Parallel efforts to design and specify the components of the Interaction Region, usually referred to as the "IR", and develop a conceptual design began in 2000. At the same time a project was initiated to design and specify the changes that need to be made in and around the C0 interaction region of the collider to support the BTeV experiment. This activity is referred to as the "C0 Outfitting" (sub)project. The implementation of all three of these components, BTeV detector, C0 Interaction Region and C0 Outfitting is referred to as the "BTeV Project".

Effective management of environment, safety, and health (ES&H) risks is a core value for the BTeV project. Such risks have been identified in the *BTeV Preliminary Hazards Analysis Report* and continue to be the subject of analysis and planning. They are evaluated and mitigated according to the policies and procedures that define the FNAL safety management system. Although this *Project Management System Description* does not focus on assurance of safety and environmental protection, the quality assurance program (Section 7) includes actions intended to ensure that appropriate safety evaluations are performed and that safeguards are specified and verified to be properly functioning.

1.2 OBJECTIVES OF THE BTEV PROJECT MANAGEMENT SYSTEM

The BTeV project management system is an integrated management control system for project planning, management, execution, cost/schedule performance measurement, analysis, and reporting. Objectives of the BTeV project management system are to:

- Plan all work scope for the project.
- Break down the work scope into finite pieces that can each be assigned to a responsible person to accomplish its technical, cost, and schedule objectives.
- Integrate work scope, schedule, and cost objectives into a performance measurement baseline plan, against which accomplishments will be measured.
- Establish, maintain, and control the baselines, databases, information, and processes necessary to manage the BTeV project successfully.

- Provide mechanisms to objectively measure, monitor, and report the status of the project, comparing the amount and actual costs of work accomplished to the baseline plan.
- Reliably detect and analyze significant variances from the plan, forecast impacts, and prepare an estimate at completion based on performance to date and work remaining.
- Ensure project risks are identified and managed appropriately.
- Establish a framework where quality is both expected and achieved.
- Meet management needs and satisfy the requirements and criteria of DOE 413.3 for an Earned Value Management System (EVMS).

The BTeV project satisfies these objectives by implementing and using a project management system that establishes clear performance baselines and provides:

- Managers, workers, and vendors appropriately skilled for their responsibilities.
- Accountability for performance/accomplishments.
- An Earned Value Management System (EVMS) based on measurable work.
- Variance analysis on major items (i.e., critical path or large dollar impacts).
- A formal Change Control Process.
- Risk identification, mitigation, and quality assurance integrated into project execution to ensure the technical, cost, and schedule baselines are achieved.
- Systematic and controlled documentation.

Given the nature of the BTeV project, its management team has elected to utilize key management systems that are already in place at Fermilab. The EVMS for the BTeV Project obtains actual cost data electronically from the FNAL accounting system and uses a combination of Welcom Open Plan® for scheduling and Welcom Cobra® for cost estimating, earned-value planning, earned-value measurement, and variance reporting. For document control, the BTeV project will use an existing document control system, which was developed in-house specifically to manage the BTeV project.

1.3 PROJECT MANAGEMENT SYSTEM IMPLEMENTATION

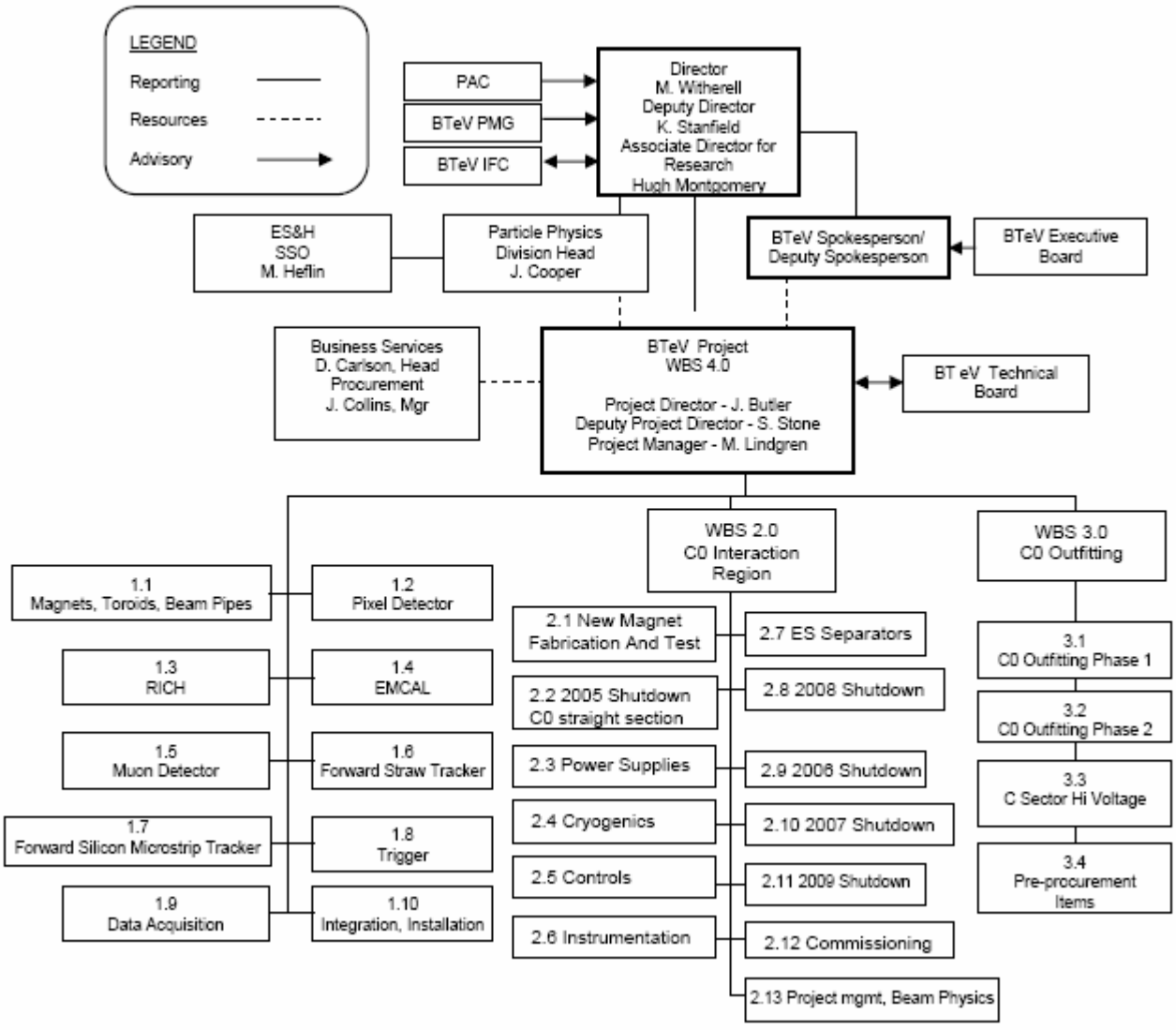
Key factors for implementing BTeV's management systems are described in later sections. They include:

- Overviewing BTeV's project management process.
- Establishing project baselines, based on a complete Work Breakdown Structure and systematic planning, estimating, and scheduling of the work.
- Objectively assessing project performance (measuring earned value).
- Calculating, analyzing, and reporting significant variances from the baseline plan, forecasting the impacts, planning and executing corrective action, and revising the estimate at completion.
- Communicating and reporting to and among project participants and with management and sponsors.
- Assuring quality and reflecting quality assurance requirements in plans and implementation.
- Identifying, managing, and mitigating project risk.
- Authorizing work systematically.
- Controlling baseline changes.

1.4 PROJECT ORGANIZATION

Fermilab's organization for the BTeV Project is shown in Figure 1.1. The purpose of the project, along with roles and responsibilities of key personnel, are described in the DOE-approved *Project Execution Plan* (PEP) (BTeV Document). The BTeV project organization, as expressed in its Organization Breakdown Structure (OBS), is closely aligned with its Work Breakdown Structure (WBS). Under the leadership of the BTeV Project director and BTeV Project Manager, the key personnel shown on the organization chart carry out the daily planning, execution and control of the project. Some key responsibilities associated with particular project management functions are described in later sections of this document.

Figure 1.1 Fermilab's Organization for BTeV Project



1.5 REVISION OF THIS MANUAL

As the project progresses, its project management systems can be expected to evolve and improve. At least annually, or whenever significant changes are implemented, the Project Manager will review this manual and propose revisions, if needed. The DOE Federal Project Director for BTeV and the Chairperson of the EVMS Certification Review Committee will each be provided a change-annotated copy and will be asked to provide a memo indicating whether the proposed changes potentially affect system certification. If in the judgment of these individuals, system certification could be affected by

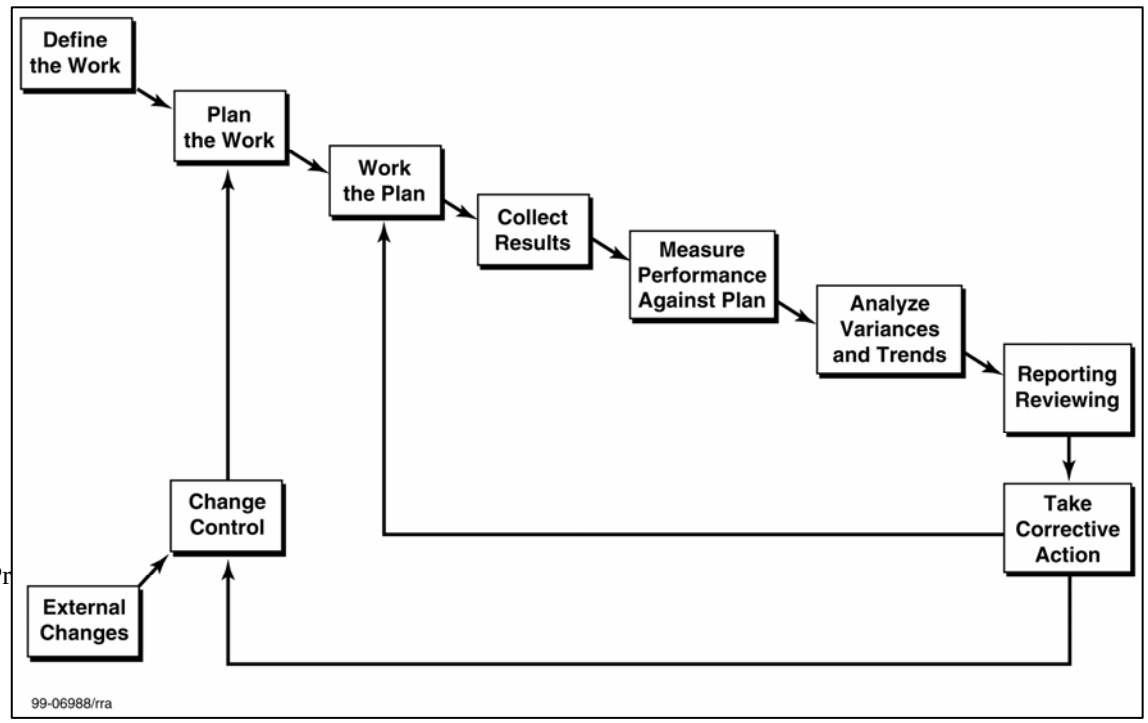
proposed changes, the project will either abandon the changes or convene a recertification review committee. The BTeV Project Director and Project Manager will each review and approve the new revision, which shall be identified by incrementing the revision number and updating the publication date. The new revision will be announced to all project participants and posted on the project web page, replacing the earlier version, which shall be archived.

Changes to personnel in organization charts or in text, changes to any sample forms presented, changes to the WBS, baseline changes, and other similar changes will not alone make it necessary to issue a revision. This document provides a snapshot of those assignments and forms. BTeV's up-to-date personnel assignments, forms, WBS, and baselines will be available via the BTeV Project's internal web page at http://www-btev.fnal.gov/atwork.

2. THE PROJECT MANAGEMENT PROCESS

The Project Management System's purpose is to provide closed-loop processes to manage and control project execution effectively. Very simply, the system is intended to ensure that all technical scope within the baseline is clearly defined and planned; work is performed; progress is measured, compared with the baseline plan, reviewed, and reported; variances from the plan are analyzed in a timely manner and alternative courses of action are developed and evaluated; the best course of action is selected; and, if appropriate, the baseline plan is modified accordingly. In addition, BTeV project management needs to be alert to developments and lessons learned from other projects at Fermilab and elsewhere, and also to share its lessons learned within Fermilab and beyond. Figure 2.1 provides a simple sketch of the management processes the BTeV's project management system must provide. An overarching requirement is that the system must produce accurate, timely, and consistent data and information that enable performance and trends to be analyzed and effective management decisions to be made in a timely manner.

Fig. 2.1 BTeV Project Management System



3. ESTABLISHING PROJECT BASELINES

To plan the work and establish performance baselines, the BTeV Project uses a scheduling system, which is also used for cost estimation. ; and a system that receives information from the lab financials database ("actuals"), correlates it with the schedule and cost estimate information and calculates Earned Value and other important project metrics. Both systems are based on a work breakdown structure (WBS) that divides the BTeV project in a hierarchical manner into sub-elements, ensuring that the scope of each item within the project is clearly defined and identified with a unique WBS number. The BTeV project selected Welcom Open Plan® (OP) for scheduling and cost estimating and Welcom Cobra® for earned-value planning (BCWS), earned-value measurement, and earned-value reporting, because these software packages were proven and functioning at Fermilab for these purposes.

3.1 WORK BREAKDOWN STRUCTURE

A Work Breakdown Structure (WBS) has been established for the BTeV Project. This WBS identifies all elements of work on the project within a logical framework that facilitates planning, budgeting, scheduling, assignment of responsibilities, cost tracking, performance measurement, and reporting of status. Modifications will be controlled through the change control process, described in the *Project Execution Plan* and in Section 10 of this document. The BTeV *WBS subproject Dictionaries* describe the scope of each WBS element.

The principal elements of the BTeV Detector sub-project, WBS 1.0, are:

WBS 1.1, the modification and installation of an existing an analysis magnet, construction of two toroids (using existing steel), and construction of beam pipes that provide the physical infrastructure of BTeV experiment; WBS 1.2, construction of a silicon pixel vertex detector to reconstruct primary interaction vertices and secondary decay vertices and which can be used in the lowest level trigger of the experiment; WBS 1.3, construction of a Ring Imaging Cerenkov counter (RICH) to provide charged hadron identification; WBS 1.4, construction of a high resolution, highly segmented electromagnetic calorimeter to reconstruct photons and π^o's; WBS 1.5, construction of a muon detector that can also be used in a stand-alone lowest level trigger; WBS 1.6, building of a forward tracker based on straw detector technology that covers large angles with respect to the beam and provides tracking in the downstream part of the detector and improves the momentum measurement obtained from the pixel detector alone; WBS 1.7, building of a forward tracker based on silicon microstrip technology that covers small angles with respect to the beam to provide tracking in the downstream part of the detector; WBS 1.8, construction of a three level trigger system, including all hardware and software, which is highly efficient for a large variety of bottom and charm decays and achieves excellent rejection of light-quark events; WBS 1.9, building of a data acquisition system and all necessary interfacing electronics and software to record all events containing a wide variety of bottom and charm decays; and WBS 1.10, installation in the C0 collision hall, alignment, integration, debugging, and technical commissioning (described below) for all components.

The principal elements of the C0 Interaction Region subproject, WBS 2.0, are:
Construction of a straight section in C0 to replace the present optics and preparation of C0 for installation of the BTeV Vertex Magnet and a wire target station for parasitic testing of BTeV detector components as they are completed, and upgrading of the C0 Interaction region to produce high luminosity, 1 to $2x10^{32}/cm^2$-s, which will enable BTeV to achieve its design sensitivity. This requires

the design of a low-β insertion to have collisions at high luminosity in the C0 Interaction Region, to construct the components to implement the design, and to install and commission the components.

The principal elements of the C0 Outfitting subproject, WBS 3.0, are:
Construction of the architectural finishes, mezzanine structures, heating, ventilation, air conditioning (HVAC), process piping systems, and power to support the BTeV detector and upgrade of the C0 Service Building, including architectural modification, HVAC and power to support the Interaction Region at C0.

The principal elements of the Project Office subproject, WBS 4.0, are:

Reviews, reports, site visits, local supervision, running technical board meetings, standards preparation, tracking and analysis, schedule preparation tracking and analysis, and change control. It also includes procurement of relevant software and computers and running the project office.

3.2 THE BASE COST ESTIMATE

The base cost estimate is made of the estimates for each entry level WBS element. It consists of an estimate of the cost of items/services to be purchased plus an estimate of the labor effort (time and type) for work planned to be done by Fermilab and personnel at universities and other national laboratories participating in the BTeV Project. The base estimate does not include contingency. The base estimate is prepared by the appropriate WBS manager, who employs the best available approach(es) to develop the estimate. The WBS manager might contact potential vendors for budgetary estimates, review catalogs, refer to recent Fermilab purchases or completed tasks with closely similar scope, use engineering estimates, or contact others with the requisite cost expertise. Each WBS manager must maintain a source book, the Basis of Estimate (BoE) book, to document the input and sources for the base cost estimate for each significant entry-level WBS element. The Project Manager is able to review the costs at any level of detail by examining the roll ups of tasks within a given class. The cost estimates provided by the Subproject Managers are reviewed by the Project Manager in consultation with any technical experts that are deemed necessary to evaluate the cost estimates The base cost estimate was obtained in FY2005 dollars as direct costs/effort, without escalating to the year the element will be accomplished. Labor rates used in the estimate were obtained from Fermilab's financial system and include all Laboratory overheads. Overhead and escalation is done external to Open Plan®, within the Cobra® accounting program that is used to compute earned value. It is foreseen that all project tracking and accounting will be done within the Cobra® structure for the duration of the Project. Note that the cost estimate is only an estimate. It is used to establish the cost baseline, but it does not commit the WBS manager to any particular vendor(s), technical approach, or split between in-house, university, and procured labor.

3.3 ESCALATION AND OVERHEADS

For preparing its resource-loaded schedule, escalated cost estimate, and performance baselines, the BTeV project used escalation rates provided by DOE in DOE M413.3-1 Project Management for the Acquisition of Capital Assets (3/28/03). The proposed funding profile (Budget Authority or BA) and escalation rates are presented in Table 3.1. For the cumulative escalation, FY 2005 is the reference year, since the base estimate was prepared in FY 2005 dollars.

Table 3.1 Funding Profile and Escalation Rates

	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010
Proposed Annual Funding (BA)	$20.6M	$41.2M	$51.2M	$51.7M	$37.4M	
Annual Escalation-M&S (%)		2.6	2.5	2.5	2.5	2.5
Cumulative Escalation – MS (%)		2.6	5.17	7.79	10.49	13.25
Annual Escalation Labor (%)		4.0	4.0	4.0	4.0	4.0
Cumulative Escalation Labor (%)		4.0	8.16	12.49	16.99	21.67

Applicable Fermilab National Laboratory overheads were applied, in accordance with Fermilab's policy for major, multiyear projects (Appendix B). Note that "base" labor rates include fringe benefits and local organizational overheads. The Laboratory's policy applies procurement overheads of 16% to the first $.5M of purchase orders, and 1.5% for amounts in excess of that.

For work contracted to institutions other than Fermilab, labor rates and overheads on labor and M&S purchases are established in Memoranda of Understandings (MOUs) for each institution.

3.4 RESOURCE-LOADED SCHEDULE DEVELOPMENT

Schedule Development

The BTeV project's resource-loaded, resource-leveled schedule was prepared using a combination of bottoms-up planning by the WBS managers, followed by a top-down management revision. The WBS managers, assisted by an expert operator of Open Plan® and Cobra®, created the fully detailed schedule. The steps followed were to: (1) enter tasks, resources, escalation rates, resource unit costs, and schedule logic into Open Plan®; (2) reschedule (i.e. delay) certain tasks to later fiscal years to level the resource (funding) requirements; (3) and further revise the timing of tasks and the level of contingency applied to resources in the early years to comply with the expected budget authority (BA) profile for the project without sacrificing schedule floats.

Step 1. The WBS manager planned the work and identified the tasks and sequence to accomplish the scope of each WBS element, along with any logic linking two or more WBS elements. Coordinating meetings were held to ensure that any links across WBS level 2 systems were identified, recognized, and included by all WBS managers involved. The level 2 manager was instructed to enter each task and its required resources (from the Base Cost Estimate) and logic into Open Plan®, and to schedule each MIE subproject activity to start in FY 2005, unless logical connections with other tasks forced it to start on a later date. Effort was spread across the duration of each task. The tasks in the Building subproject schedule were scheduled into Open Plan® consistent with typical conventional-construction design-bid-construct logic and the dates specified in the architect/engineering contract already underway. Logical links and joint milestones involving all subprojects were also input into Open Plan® during the development of the Open Plan® schedule database. Many iterations between the Open Plan® scheduler and each WBS manager allowed the entered data to be checked against the plan, errors to be corrected, and schedule refinements to be developed. The complete resource-loaded Open Plan® schedule resulting from this approach represents the technically driven schedule, ignoring funding and resource constraints.

Step 2. After all of the WBS activities, resources, and logic were loaded into Open Plan, the project team 'leveled' the schedule to fit within the expected budget profile as provided by the Fermilab Directorate in consultation with OHEP. The funding profile had a relatively low amount of funding in the first year of the project and a large amount of funding in the last year of the project. Fitting into this funding profile required several iterations. Procurements that could be awarded as phased contracts, with a partial commitment in the early years of the project were identified, along with the minimum acceptable value for the first phase. The remainder of the budget required for this procurement was shifted into the following years for subsequent phases. This schedule planning and resource leveling was done in Open Plan® by making resources each year available first to the most critical paths in the project, to ensure their progress would be minimally impacted by funding limitations, and also to the required project management/control tasks. The scientific equipment items were reviewed to identify those that could be delayed without impacting the critical path. In addition, the suite was reviewed to identify items that would be critical to have available early. At that point, the procurement award date for scientific equipment items that could (or should) be delayed to FY 2007, or later were moved in Open Plan® to those years. Those that were judged critical for FY2005 were designated for early procurement and moved to that year in Open Plan®. This rescheduling process continued for several iterations.

Step 3. Management further revised the timing of tasks and the level of contingency applied to resources in the early years to ensure that the resources required in each year remained within the funding profile and adequate schedule float existed in every subsystem to ensure a high probability of delivering the full project scope on schedule and within budget. The resulting schedule is, consequently, not a technically limited schedule.

The result of this three step process was BTeV's resource-loaded, resource-leveled schedule.

Cost/Obligation Schedule Profiles

Management needs several different cost/schedule profiles in order to be able to fulfill all of the project's scheduling, information, and reporting needs. Open Plan® and Cobra® provide the tools needed to maintain only one schedule in Open Plan®, with the ability to toggle between profiles based on the type of information required. Initially, there are three profiles that are needed: an aggressive working schedule "management" profile, a performance measurement "cost" profile, and an "obligation" profile. All three profiles can be obtained by manipulating the Open Plan® master schedule using global edits. The appropriate schedule profile is then brought into Cobra® (where escalation is applied) for reporting purposes.

The first global edit (schedule contingency global edit) allows management to toggle between schedule float distributed throughout the project or pushing the entire schedule float to the end of the project. The second global edit (cost global edit) allows management to distribute the cost of material and services (M&S) resources to different points in time, in order to identify an "obligation" profile (where the cost must be "loaded" at the beginning of the task in order to obtain budget authorization in the appropriate fiscal year) and a "cost" profile where M&S costs are distributed linearly across the length of the task, or loaded at the end of the task when the goods or services are expected to be received.

The "management" profile is the schedule that the project will aggressively try to work towards. This profile pushes the entire project schedule float to the end of the project using the schedule contingency global edit. In order to work to the "management" profile, the project will need budget authority (BA) at the time the obligations will be made. The project's cumulative obligations are not permitted at any

time to exceed the cumulative amount through each fiscal year that has been appropriated by Congress and transferred to Fermilab by DOE. The "obligation" profile was obtained by using the "management" profile schedule (all schedule float pushed to the end of the project) and applying the cost global edit to shift M&S costs to the start of their tasks.

The performance measurement or "cost" profile was obtained by taking the "management" profile schedule, applying the schedule contingency global edit to distribute float throughout the project (on or near the critical path), and applying the cost global edit to distribute the cost of the M&S resources at the end of the task when the goods or services are expected to be received. The schedule with the "cost" profile is the project's performance measurement baseline (PMB). It is loaded into Cobra®, and appropriate escalation rates are applied to create the Budgeted Cost of Work Scheduled (BCWS). The BCWS is intended to closely reflect when work would be accomplished and costs incurred and will be used for Earned Value management and reporting.

The cost profile schedule was then baselined in Open Plan® and brought into Cobra®. Escalation rates were applied in Cobra®, providing the performance measurement baseline and the escalated baseline cost estimate. The Open Plan® schedule and the Cobra® performance measurement baseline are controlled, maintained, and statused as described in Section 3.6.

3.5 SCHEDULE HIERARCHY

The BTeV schedules are "tiered" from the Project Summary Schedule diagram presented in the PEP to the detailed project schedule in Open Plan®, to informal daily/weekly task schedules that might be maintained and used by WBS managers. The schedule in Open Plan® and the resulting BCWS in Cobra® comprise the performance baseline, and are subject to formal change control after receiving CD-2/CD-3a approval.

The Major Milestone list in the PEP presents the project's highest level schedule commitments. To mitigate schedule risk, up to 6 months of float has been added to the date in the detailed schedule to establish conservative baseline dates for the Major Milestones. The Project Summary Schedule is a diagram, which includes the major milestones presented in the PEP, the major DOE reviews, DOE quarterly reviews, and hammock-like summaries showing the duration of the different stages (design/specify, procure/fabricate or construct, and install/test) of work on each WBS system. The Baseline Milestones in the Summary Schedule, their definitions, and their baseline dates were mutually developed by BTeV Management and the DOE Federal Project Director for BTeV. Logic in the Open Plan® schedule links precursor tasks to the Major Milestone baseline dates, so project management and other personnel can monitor the float status of these milestones, and take corrective action proactively if float reduces below an acceptable level.

WBS managers are encouraged to have and maintain for their own use informal, detailed daily/weekly work/task/assignment schedules for any subsystem where such a schedule would be helpful.

3.6 COST AND SCHEDULE BASELINE MANAGEMENT

The BCWS in Cobra® is the performance measurement baseline (PMB). The schedule in Open Plan® is the baseline schedule. Both are subject to project change control. As work is accomplished, it is recorded in Open Plan®, with the status then imported into Cobra®. The budgeted cost within Cobra® of the accomplished work becomes the Budgeted Cost of Work Performed (BCWP). Actual costs

incurred or accrued are imported into Cobra® each month, directly from the Fermilab financial system, becoming the Actual Cost of Work Performed (ACWP). Then Cobra® integrates the performance measurement components to produce monthly earned value reports, calculate variances, and provide reports and graphs for use in project management.

The schedule baseline (Open Plan®) and PMB can only be revised using the change control process. The approved thresholds and change control process are described in the PEP , for Level 0,1, and 2 changes and in the PMP for Level 3,4, and 5 changes, and are repeated ,in Section 10 of this *Project Management System Description*. Approved changes will be incorporated into the schedule (Open Plan®) and performance baselines (Cobra®). Future statusing will be compared to the revised baseline. Schedule changes can only affect future work, and cannot retroactively change BCWS, BCWP, or ACWP. Time is of the essence in the disposition of proposed baseline changes and incorporation of those that are approved.

At the time each Request for Proposal (RFP) is issued or each contract is placed, the cognizant WBS manager can issue a Level 5 change order directing that the default resource loading for a specific procurement be changed to more accurately reflect the contracted BCWS (e.g. progress payment milestones and schedule), so long as the contracted or revised plan finishes the work on or ahead of the project's baseline schedule and at or below the baseline estimate for the item. If the contracted cost/schedule exceeds the baseline budget/schedule for an item and if it is desired to change the baseline, a Project Change Request must be used and approved per the baseline change process described in the PEP, PMP, and detailed in Section 10 of this document.

3.7 RESPONSIBILITIES

The Project Manager is responsible for maintaining the WBS dictionary, the detailed schedule baseline in Open Plan®, the cost estimate and PMB in Cobra®, the change control process, and project documentation. This responsibility includes assuring the integrity and documentation of the processes, databases, and data. Monthly he/she will in a timely and accurate manner collect estimates of work accomplished from WBS managers and status progress, spot check earned-value reports, perform a critical path analysis, perform major milestone status analysis, generate EVMS reports and graphs in formats required by the project team, and draft the BTeV project's monthly progress report to DOE. On an as-needed basis, the Project Manager will implement approved enhancements to the EVMS and at least annually reviews and (if necessary) updates this *Project Management System Description*, subject to the approval of the BTeV Project Director, and the DOE Federal Project Director.

The WBS managers are responsible for estimating, planning, and performing work in their WBS systems and for ensuring interfaces and obligations with other WBS systems are satisfied. They are responsible for accomplishing the work within the approved technical, cost, and schedule baselines, for accurately assessing and reporting work accomplished on a monthly basis, for analyzing and recovering from significant variances, and evaluating the adequacy of the estimate to completion (ETC).

Each project participant is responsible for alerting the next higher level manager of information, trends, or concerns that could affect successful accomplishment of the BTeV project's cost, schedule, and technical baselines. In addition, each person shall notify the Project Manager of possible errors in the Open Plan® and Cobra® files.

4. EARNED VALUE MEASUREMENT

4.1 EARNED VALUE MEASUREMENT REQUIREMENTS

All work progress will be assessed using earned value (EV) techniques. Budgeted Cost of Work Scheduled (BCWS) is the time-phased budget that represents the value of work to be accomplished through a given period of time. As work is actually completed, budget associated with this work is "earned" as Budgeted Cost of Work Performed (BCWP). Budgeted Cost for Work Performed is synonymous with "Earned Value." The following guidelines are followed in determination of BCWP:

- Earned value is determined using the method selected at the time the activity is planned.
- Every scheduled activity within a work package that has resources assigned to it must also be assigned an earned value method (code).
- The selected measurement method does not change for the duration of the activity.
- Earned value is determined in a manner that is consistent with the way BCWS is planned.
- Earned value (BCWP) is recorded at the end of each accounting period and before actual costs are known.
- Retroactive adjustments are not made to BCWP previously reported, except to correct mistakes in reporting.
- BCWP can never exceed budget at completion (BAC) for any work package.

4.2 EARNED VALUE MEASUREMENT TOOLS

BTeV has adopted EVM tools and systems previously accepted by DOE. These tools include Welcom Open Plan® for schedule logic, Project Baseline Definition, and work package progress entry. Welcom Cobra® is used for cost capture and earned value and variance calculation and reporting. The personnel involved in the BTeV project at Fermilab have set up and created the BTeV project management databases, the schedule, and the baseline. Section 3 provides information about how the Open Plan® and Cobra® databases were created, are controlled, and interact with each other and with the BTeV project team.

4.3 EARNED VALUE PLANNING AND MEASUREMENT

The BTeV Project Manager and appropriate WBS manager will agree on an earned value method when authorizing the start of work on each work package. The Project Manager supports this process and creates and manages the associated documentation. The earned value method options for the project, which are called "performance measurement techniques" (PMTs) in Cobra®, are as follows:

- PMT Code B: Milestone Method. The milestone method is the industry standard method for assessing progress on work packages that span more than two fiscal periods. It can be used on tasks of any duration that have deliverables or milestones, and will be used when practical for activities greater than 6 months in duration and more than $100K in value . The work package is planned with several milestones specified. Each milestone has its scope/deliverable described and is assigned a value. The sum of the values of all milestones equals to the budget at completion (BAC) for the task. The BAC is the cumulative BCWS for the task. Each milestone

is represented in Open Plan® as a one-day activity with resource value equal to the milestone value. Earned value (BCWP) is earned as each milestone is completed. For procurements with multiple deliverables, a reasonable approach is to assign a value to each deliverable and to place each deliverable as a one day activity with that value into the Open Plan® schedule.

- PMT Code C: Percent Complete. The percent complete method is intended to be used on short duration tasks of no more than six months' duration or low-value tasks budgeted at less than $100K. The percent complete of the activity in the detailed schedule is used to calculate earned value, by multiplying the percent complete by the total value of the task.

- PMT Code A: Level of Effort (LOE) . The Level of Effort method will be used only where there are no definable deliverables (milestones) or when tasks and activities are administrative in nature. Earned value on LOE activities is equal to BCWS.

Within the current year a task can be divided into several activities, each with definite scheduled start and completion dates. When practical, activities longer than six months in duration should have intermediate milestones that provide an objective 'yardstick' for measuring how the work is progressing.

4.4 PLANNING AND MEASURING PROCUREMENTS

Procurements can be planned and measured using any of the above methods. For procurements, value will not be earned unless costs are either incurred or accrued through the Fermilab accounting system, to ensure that the cost variance is not favorably biased. Thus, it is desirable for earned-value milestones to mimic progress payment milestones/deliverables specified in the contract or otherwise agreed with the vendor. For procurements where full payment is made after delivery, no earned value will be planned or taken until delivery, unless costs are accrued. At about the time the contract is awarded, the appropriate WBS manager may submit a Level 5 change order to adjust the BCWS spread to reflect the vendor's proposed schedule of progress payments and milestones, so long as the new spread does not represent a cost increase or schedule delay to the total task.

Procurements are allocated sufficient budget in one fiscal year to complete the procurement, even if milestones and deliverables are expected in a subsequent fiscal year. Deliverables and milestones must be specified for the full length of the task. Alternatively, the budget available for a procurement may be phased across two (or three) fiscal years, and each year would have a separate work package with budget for the second phase in the second fiscal year, with detailed deliverables and milestones enabled by the phase two funding being specified at that time.

4.5 WORK AUTHORIZATION AND WORK PACKAGES

The work package is the tool the BTeV project uses to allocate funding to, authorize work on, and measure the progress of any project task. Work packages are created from the detailed project schedule and developed by the responsible WBS manager to cover the scope of work planned for the year and to allocate the appropriate budget. Each work package covers a distinct set of WBS elements, usually at Level 3 or Level 4 in the WBS. It describes the activities in lower-level WBS subelements planned to occur during the year. Each work package must identify the EV method and resource loading for each activity. Approval by the Project Manager authorizes the work. The sum of the actual cost of all work packages completed and the funding authorized to all open work packages cannot exceed the cumulative budget appropriated and authorized for the BTeV project during the year. Work

packages may be opened at any time during the fiscal year. The opening of a work package is the method the project uses to formally allocate funding to and authorize work. The baseline schedule from Open Plan® and the time-phased budget from Cobra® would typically be incorporated in or attached to the work package.

Each work package will include:
1) The narrative description of the scope of work.
2) Total BA requirements by month for the work package.
3) The total BA required for the full year for each lowest level WBS element in the work package.
4) BCWS profiles by month from Cobra® for each lowest-level WBS element.
5) The detailed resource-loaded schedule from Open Plan® of activities planned for the fiscal year.
6) The proposed earned value method for each resource-loaded activity.

No work package will be allowed to combine resources from Fermilab with those of universities or other collaborating institutions.

4.6 MEASURING WORK PROGRESS TO EARN VALUE

The appropriate WBS manager will report at the end of each month on the status or progress (earned value) and adequacy of ETC for each work package that is authorized. Actual start and/or completion dates will be reported by the WBS manager and entered into Open Plan® by the BTeV Scheduler, producing a current working schedule. Comparing the working schedule dates to the baseline schedule dates will define variances. Schedule logic will allow the impact of behind-schedule activities on downstream events to be reported and summarized and the critical path to be analyzed.

To start collecting earned-value status each month, the Project Manager will issue Status Update Requests to the responsible WBS manager not later than the third to the last working day of the month. The WBS manager will review the schedule status for each open work package, prepare the Status Update Report, and return it to the Project Manager by the third working day of the next month. Upon receipt of the Status Update Report, the BTeV Scheduler updates the detailed schedule in Open Plan®. After updating the detailed schedule, the BTeV Scheduler will perform an analysis of the critical path, the key milestones and the high risk activities in the project to determine the current status of the project schedule contingency. The milestones scheduled to occur in the next 6 months, to Tier 4, will be put into a Gantt chart that will display the baseline date, the current forecast date, and any variation in the current forecast date from the previous month. This Gantt chart will be given to the Project Manager by the 10th working day of the month, and will be presented at the monthly PMG meeting and included in the Projects monthly DOE report. The WBS managers validate/approve the updates to be sure they accurately reflect the status. In parallel, the Project Manager and/or Project Director spot check one or more random status reports to validate their accuracy, and then analyze the schedule for potential impacts to the project critical path, for impacts to Level 1-4 milestones, and to identify any other schedule trends, issues, or concerns that warrant management attention.

The BTeV Scheduler provides a copy of the statused schedule to the Project Budget Officer by the 8th working day of the month. The Budget Officer integrates the information from the statused schedule into Cobra® to calculate earned value (BCWP).

4.7 ESTIMATE TO COMPLETE AND ESTIMATE AT COMPLETION

The BTeV Project will explicitly track the amount of funding needed to complete the approved scope of work, which is called the Estimate to Complete (ETC). The sum of ETC and the actual cost of work completed is the Estimate at Completion (EAC). Automatically each month, Cobra® projects and reports the EAC as the sum of the actual costs to date plus the current BCWS for remaining work. Note that the current BCWS includes any approved baseline changes. In addition, each month, the WBS managers will evaluate the adequacy of the current ETC.

A comprehensive "bottoms-up" reevaluation of ETC may be initiated at any time at the discretion of a WBS manager (for his/her system), of BTeV Management, or of DOE. The method used to prepare this estimate is the same as was used to prepare the original base estimate (see Section 3.2). Typically the project would make such an estimate prior to a major project review by DOE. BTeV management will report the result of the revised estimate and will use it to manage cost/schedule risk, to pursue more cost-effective technical approaches, and/or in other ways to guide project execution. The option exists to use the change control process described in the PEP, PMP, and repeated in Section 10 of this document to propose a baseline change to formally adopt the updated ETC/EAC as the project baseline. An alternative option is to continue to manage to the existing baseline, carrying, explaining, and recovering from the variances that arise.

WBS managers must notify BTeV management promptly, whenever they become aware of new information that indicates likely significant changes in the EAC of their systems.

5. VARIANCE ANALYSIS AND REPORTING

An important part of the BTeV Project Management System is the quantitative measurement of cost and schedule variances from the baseline plan, and the use of this variance information in project management. These variances are determined by comparing three parameters: the Actual Cost of Work Performed (ACWP), the Budgeted Cost of Work Performed (BCWP), and the Budgeted Cost of Work Scheduled (BCWS), which represents the baseline plan. The BCWS and BCWP were introduced in Section 3. The ACWP comes from the Laboratory's financial/accounting system.

Every month on about the 3rd working day, actual (and any accrued) costs for the previous month for BTeV project work packages are obtained by the Project Budget Officer in electronic form from the Fermilab financial/accounting system. Data from the financial system are not altered. The actual cost data are imported in electronic form into Cobra® by the 6th working day of the month. These data are the ACWP for BTeV tasks. After the schedule status information is imported into Cobra®, the ACWP, the earned value (BCWP), and BCWS are used by Cobra® to produce monthly earned value reports, calculate variances, and provide reports and graphs for use in project management not later than the 15th working day of the month. These reports, variances, and graphs are reviewed and validated by the Project Manager, consulting with the WBS managers and the BTeV Scheduler. If there are errors related to actual costs, they are corrected in the accounting system in the following month.

5.1 REQUIREMENTS

- Progress (earned value or BCWP) is determined on a monthly basis for all active work packages, before actual costs are known.

- Actual cost (ACWP) data is obtained directly from the Laboratory financial system, is validated, and is imported into the cost processing module (Cobra®).
- Current month and cumulative-to-date cost and schedule variances are calculated and reported. The cost variance is the BCWP less ACWP. The schedule variance is BCWP less BCWS.
- At-completion estimates (EAC) and variances are calculated based on actual costs to date and the budgeted cost for work remaining to be performed.
- Cost Performance Reports (CPR) in formats desired by management and sponsors are produced.
- Cost and schedule variances that exceed established thresholds (Table 5.1) are analyzed, variance analysis reports are prepared, and variance explanations are included in the monthly progress reports at the designated levels.
- For unfavorable variances exceeding thresholds (Table 5.1), corrective action plans are prepared by the WBS managers and are tracked until the work is completed or the variances are within acceptable limits.

5.2 ACTUAL COST DATA

Monthly actual cost data are acquired electronically at the work package level from Fermilab's DOE-approved accounting system by the 3rd working day of the month. Actual costs entering the accounting system include labor charges, materials and services, overhead costs, and accounting transfers and accruals. Labor costs are charged to the project via payroll and the Lab's effort reporting system. Materials and Services costs include approved invoices, travel expenses, petty cash expenditures, and ProCard purchases. Overhead costs, accounting transfers, and accruals are charged to the project by the accounting department. The actual costs are captured in a file that is imported directly into Cobra® by the Project Budget Officer to produce the ACWP. The Project Budget Officer reviews the actual cost file to (1) ensure that costs are reported for all work packages where progress is reported, and (2) check for obvious accounting errors and misplaced charges. The Project Budget Officer sends an email to the appropriate WBS manager(s) and Project Manager listing any discovered mismatches of type (1) and errors of type (2). Then the Project Budget Officer works with the Accounting Department to correct any errors. The corrections would be reflected in the following month's accounting reports.

The BTeV project management recognizes that reported cost performance can be favorably biased if invoiced/booked costs lag behind the reporting of value earned. This bias can be minimized by either of two techniques: by delaying reporting earned value until invoices enter the accounting system, or by accruing in the accounting system each month the cost expected for the completed/claimed work. Since delaying earned value reporting causes an apparent unfavorable schedule variance, accrual of costs is preferred. Accrual of costs is a labor intensive, manual process, but will be employed where the distortion could be greater than $1,000.

The Project Budget Officer uses Cobra® to produce standard EVMS reports and graphs monthly, presenting cumulative to date and monthly BCWS, BCWP, ACWP, and variances. The full set of reports and graphs is distributed to the BTeV Project Director, BTeV Project Manager, and WBS managers, for use in managing the project going forward. Reports requested by the DOE Federal Project Director are provided to him, and specific summary reports are included in the BTeV Project's formal monthly progress report.

5.3 COST AND SCHEDULE VARIANCES

Variances capture the difference between the plan and the actual cost and schedule of work accomplished. Using the data in the EVMS, cost variances are calculated as described below each month for the project as a whole, at WBS level 2, and down to the cost account level. Schedule variances are calculated at the work package level.

5.3.1 Cost Variance—Cost performance is measured against the plan by comparing the value of work accomplished (BCWP) to its actual cost (ACWP). Cost variances are expressed as follows:

Cost Variance (CV) = BCWP - ACWP
Percent Cost Variance = [(BCWP - ACWP)/BCWP] x 100

Positive variances indicate a cost under-run condition: more work was accomplished than money was spent. Negative variances indicate a cost overrun condition.

A Cost Performance Index (CPI) will be utilized where:

CPI = BCWP/ACWP

CPI values less than 1.0 represent “cost overrun” condition (“bad”) and values greater than 1.0 represent “cost under run” condition (”good”).

5.3.2 Schedule Variance—Schedule performance is measured by comparing work accomplished (BCWP) against the plan for work scheduled (BCWS). Schedule variances are expressed as follows:

Schedule Variance (SV) = BCWP - BCWS
Percent Schedule Variance = [(BCWP - BCWS)/BCWS] x 100

Positive variances indicate an ahead-of-schedule condition: more work was accomplished than was scheduled. Negative variances indicate a behind-schedule condition.

The schedule variance for any task or system can be converted into time by comparing the present date with the date the BCWS was supposed to equal the current BCWP.

A Schedule Performance Index (SPI) will also be used where:

SPI = BCWP/BCWS

SPI values less than 1.0 represent “behind schedule” condition (“bad”), and SPI values greater than 1.0 represent “ahead of schedule” condition (“good”).

5.4 VARIANCE ANALYSIS

Variance analysis is performed when cumulative cost and/or schedule variances exceeding predetermined thresholds exist in WBS Level 3 or higher systems. Variance thresholds are established for the Project (Level 1) and for Level 2 and Level 3 systems, both as percent and dollar variances (See Table 5.1). Both conditions (CPI/SPI and SV/CV) must be met to exceed threshold. Every month, the Project Manager uses Cobra® to produce a variance summary for the entire project, down to the work package level, with roll-ups at each higher WBS level. Those Level 1, 2, and 3 systems where cost or schedule variances exceed thresholds are flagged. In cases where both the dollar threshold and the CPI/SPI limits are exceeded, written variance reports are required. It is the responsibility of the

appropriate WBS manager to provide the required variance reports to the Project Manager, and to develop and implement corrective action plans, if needed.

Table 5.1 Variance Analysis Thresholds (Cumulative)

	Threshold CPI or SPI	Threshold SV or CV Dollar Value	Threshold SPI for Critical Path Element
WBS Level 1	<0.95 or >1.05	Overrun > $400 K	N/A
WBS Level 2	<0.92 or >1.08	Overrun > $100 K	N/A
WBS Level 3	<0.90 or >1.1	Overrun > $30 K	<0.98 or >1 week

The variance analysis section of the monthly report to DOE contains the BTeV Project Manager's summary of the significant variances, their causes, their likely impacts, and a description of corrective action(s) taken or planned. Significant cost variances likely to be sustained would be reflected in the EAC.

5.5 EVALUATING TRENDS AND MONITORING CORRECTIVE ACTIONS

Trends in project performance will be tracked and evaluated by the Budget Officer on behalf of the Project Manager. Trending includes monitoring changes in the earned value and variances over time.

It is the WBS manager's responsibility to monitor and report corrective actions until variances are resolved. The normal forum for this reporting is at the weekly Technical Board meetings. The Project Manager also reviews the status of corrective action plans during his routine meetings with each WBS manager.

6. COMMUNICATION AND REPORTING

Timely and accurate communication among project participants and stakeholders is a key element of the BTeV Project Management System. This communication includes routine and *ad hoc* meetings, project documents, design drawings and specifications, informal emails, and reporting. The goal of project communication and reporting is to keep project participants and stakeholders sufficiently knowledgeable and up-to-date on important plans and status that they can fulfill their project-related obligations efficiently and effectively. These obligations include satisfying reporting requirements to sponsors, regulators, and management, including fulfilling commitments established in the PEP.

6.1 MONTHLY PROGRESS AND COST PERFORMANCE REPORT FOR DOE

The Monthly Progress Report to DOE, containing a narrative summary of progress on the entire BTeV project along with EVMS summary data and graphs for the MIE subproject, is one of the key reports. Per the PEP, the narrative summary report will be provided to the DOE Federal Project Director for BTeV and to the program manager in the Office of High Energy Physics (OHEP) at DOE HQ starting when CD-1 is approved. BTeV expects to receive CD-1 approval in November 2004, and begin producing narrative monthly progress reports at that time. EVMS data for the project will be included

in the Monthly Progress Report when the performance baseline is formally established after DOE approval of CD-2 in FY 2005.

The Budget Officer will draft the Monthly Progress Report for review and submittal by the BTeV Project Manager, preparing the required EVMS data and graphs for it. The monthly Status Update Request issued electronically to the WBS managers by the Project Manager will request a brief narrative summary of progress, status, and issues, as well as work-package schedule status for earned value measurement. The EVMS data and graphs in the Monthly Progress Report will satisfy DOE 413.3 requirements for the Cost Performance Report (CPR) for the MIE subproject. The variance analysis section of the monthly report to DOE contains the BTeV Project Manager's summary of the significant variances, their causes, their likely impacts, and a description of corrective action(s) taken or planned. After reviewing and finalizing the Monthly Progress Report, the BTeV Project Manager submits it to the BTeV Project Director for approval and submittal to the DOE Federal Project Director. Information copies are provided to the WBS managers and other members of the Integrated Project Team.

The BTeV Project has been entered into DOE's Project Assessment and Reporting System (PARS). The DOE Federal Project Director for BTeV will provide monthly updates to PARS for the MIE sub-project, starting at CD-2. The BTeV Project Manager will ensure that the Federal Project Director has the information required to make the updates.

6.2 PARS REPORTING

Prior to CD-2, project status will be entered in the PARS narrative section at the end of each month for the preceding month. Subsequent to CD-2, earned value data will be entered by the end of each month for the preceding month. The following color codes, as stated on the PARS web site, will be used. Any rating other than "green" will need to be explained in the PARS narrative section.

"Performance indices (CPI and SPI) are commonly used for project assessment. To assist senior management with interpreting the range of values, color thresholds have been created to categorize projects. These thresholds are based on cumulative cost and schedule performance indices (CPI_PTD and SPI_PTD), and are assessed on projects that are beyond the definition stage. Generally speaking, an index value less than 1 is unfavorable, and a value greater than 1 is favorable. The current guidelines for the color coding are:

GREEN if the performance index is between .90 and 1.15.

YELLOW if the performance index is between .85 and .89 or if the performance index is between 1.16 and 1.25. The project will also be categorized yellow if it has not been updated in PARS within the past 45 days.

RED if the performance index is below .85 or above 1.25 (any value outside of green or yellow)."

(CPI - Cost Performance Index. CPI=BCWP/ACWP; SPI - Schedule Performance Index. SPI =BCWP/BCWS)

6.3 UNIVERSITY REPORTING

The BTeV Collaboration is composed of a large number of scientists from universities and national laboratories. Several of the large subprojects are the main responsibility of University groups, and managing, communicating, and reviewing the university led efforts must be a high priority to ensure project success. Each university group will report its activities monthly by contributing to the subproject narrative included in the DOE monthly report detailed above. In addition, the project has developed a monthly cost report that each university group with an MOU and SOW will update on a monthly basis. The template for the cost report is shown in Figure 1.

Cumulative Costs through 9/30/04																			
											PO Sxxxxxx								
Project #	Task #	PO Line	Description of Work	MOU Total	FY05 SOW	FY06 SOW	FY07 SOW	FY08 SOW	FY08 SOW	PO Total	Cumulative Work Completed Prior Periods	Work Completed Current Month	Work Completed To Date	% Comp	Work Remaining to Complete	Unauthorized Total		
460		1																
460																		
460																		
460																		
			WBS# Task Totals															
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460																		
460																		
			WBS# Task Totals															
			Grand Totals	0.00	0.00	0.00			0.00	0.00	0.00	0.00	0.00	0	0.00	0.00		

Figure 1 – Sample University monthly reporting form

6.4 MEETINGS AND REVIEWS

The BTeV Project uses a series of regularly scheduled meetings and reviews to manage, communicate, and drive the project's technical, schedule, and cost progress. These meetings provide a forum for anticipating and resolving emerging problems, revealing early indications of developing trends and problems, keeping project activities coordinated, and keeping participants informed. The BTeV project secretary maintains a master schedule of regular and special project meetings and reviews, and interested personnel are welcome to attend.

6.3.1 Weekly Technical Board Meetings. The Project Director and Project Manager co-chair weekly meetings attended by the WBS managers and Project Support Staff to coordinate and expedite work and plans, discuss and evaluate proposed changes (see Section 10), discuss and evaluate risks and mitigation strategies (see Section 8), and generally to identify and resolve project issues.

6.3.2 Routine WBS Level 2 System Meetings. Each WBS manager will chair and convene routine meetings of participants and stakeholders involved in the planning and execution of the system scope. The purpose of the meetings is work assignment, planning, coordination, and trouble shooting, etc. The frequency of these meetings will range from weekly to monthly to as needed, depending on the nature of the system and the activities underway.

6.3.2 Monthly Progress Meetings. Once CD-2 approval is granted, progress meetings will be held monthly to review the status of each WBS Level 2 system from the viewpoint of cost, schedule and scope. The meetings are held shortly after EVMS reports and graphs are provided by the Budget Officer and before the monthly progress report is submitted to DOE. The Project Director and Project Manager co-chair these meetings. The status review format shall be simple, straightforward and

concise. Utilizing trend charts for cost and schedule performance, each WBS Manager shall present task status, including the following:

- Technical Accomplishments
- Schedule and Cost Status and Variances
- Estimate of EAC
- Procurement Status
- Significant Issues/Problems
- Key Activities and Milestones planned in the next 60 days

6.3.3 Design Reviews. As needed based on risk analysis or system significance and uniqueness, the BTeV Director, Project Manager, or WBS managers will convene meetings to review the preliminary design and final design of systems and subsystems for which such reviews are appropriate. Reviewers will include independent technical experts, knowledgeable project personnel, and/or scientists who will use the system/subsystem when it is complete. The purpose of the design reviews is to validate the technical approach, feasibility, design soundness, cost effectiveness (value engineering), etc. of the design, including its ability to achieve the technical goals.

6.3.4 Independent Internal Reviews. The BTeV Director has established an Internal Independent Review Committee to advise him on the progress and status of the BTeV project, ensure it satisfies Laboratory and DOE requirements, and help keep the project on track. This committee is convened on an as-needed basis, approximately twice a year. It will review the detector, IR and C0 Outfitting subprojects and the Project Office.

6.3.5 DOE Reviews. The Director of OHEP, is expected to convene routine semiannual reviews of the BTeV Project . Fermilab's BTeV project team will support the DOE Federal Project Director's preparation for these reviews. In addition, OHEP charters major reviews of the BTeV project's overall technical, cost, schedule, and management status, starting with the CD-1 Review in April 2004. These review committees include independent peers from DOE and from other organizations who have expertise in the technical and management fields essential to project success. DOE has established an Energy Systems Acquisition Advisory Board (ESAAB) process for reviewing the readiness of projects for approval of Critical Decisions. The ESAAB reviews of the BTeV project will occur on an as needed basis to support DOE oversight and review.

7. QUALITY ASSURANCE

Section 7.1, Quality Assurance Overview, repeats the Quality Assurance (QA) Plan in the BTeV Project Management Plan. Its purpose is to establish the QA requirements for the construction phase of the BTeV Project. This overview describes how project activities will be conducted in accordance with the Fermilab National Laboratory Quality Assurance Program described in policy 10. It establishes a framework where quality is both expected and achieved. Because quality can have a direct impact on technical performance, cost, schedule, safety, and the environment, by far, the cheapest, fastest, and safest way to implement the BTeV Project is to do everything safely and correctly from the start, and to avoid the need for rework. Sections 7.2 contains some additional guidance in helping the Level 2 managers plan and execute the QA plan effectively,

7.1 OVERVIEW

Quality Assurance is an integral part of the design, fabrication and construction of the BTeV Project. Special attention is paid to items that are most critical to the schedule and performance requirements of the Project. All work performed at Fermilab will draw on the guidelines and criteria set out in the Fermilab Quality Assurance Program (FQAP). These include:

- management criteria related to organizational structure, responsibilities, planning, scheduling, and cost control;
- training and qualifications of personnel;
- quality improvement;
- documentation and records;
- work processes;
- engineering and design;
- procurement;
- inspection and acceptance testing;
- assessment

Quality Assurance and Quality Control (QA/QC) systems are designed, as part of the Quality Management Program, to ensure that the components of the detector meet the design specifications and operate within the parameters mandated by the requirements of the High Energy Physics Program. The Quality Management Program can be found in Appendix C of the PMP. The QA/QC elements currently in place for the BTeV Project draw heavily on the experience gained from past detector construction projects. Senior management recognizes prompt identification and documentation of deficiencies, coupled with the identification and correction of the root causes, are key aspects of any effective QA/QC Program. The Project Manager endorses and promotes an environment in which all personnel are expected to identify nonconforming items or activities and potential areas for improvement.

Detector components are fabricated specifically for BTeV by either commercial vendors, other Department of Energy Laboratories, member universities within the BTeV Collaboration, Fermilab owned facilities, or some combination of the above. The items manufactured may be individual components, detector sub-assemblies, or a complete piece of upgraded equipment being installed as part of the Project. One example of a complete assembly would be the RICH detector, supplied by Syracuse University. It is the responsibility of the Project Manager and/or Project Leaders to have adequate verification methods in place to assure that only properly trained, qualified, and certified personnel are involved in the design, manufacture, and installation of detector components.

All components must be fabricated to pre-determined design specifications that will allow them to operate properly when integrated into the total system. Agreements will be in place with each vendor that explicitly state the operating parameters of the piece or pieces they construct. These agreements will also assign the responsibilities for testing and verification of the final product. Procured items must meet established requirements and perform as specified. In some cases, random testing of a certain percentage of components will be performed and documented by an independent organization. In the event that non-conforming items are discovered, they will be documented and controlled to preclude inappropriate use until compliance with the applicable technical requirements is demonstrated. Vendor qualifications are reviewed as part of the bid process and are taken into consideration prior to bids being awarded. Vendor site visits may be conducted periodically

throughout the duration of the fabrication contracts to ensure quality requirements are understood and being adhered to properly. Every electronic system should have as an essential part of its deliverable a fully documented testing and trouble shooting procedure.

Within Fermilab facilities, a Traveler will accompany each component through the assembly process. These information packets are used to identify, report, correct, and trend non-conformance situations adverse to quality detector performance. The Travelers will contain whatever historical information accompanies the equipment, list the specified operating parameters, and provide a place for testing results to be entered. The test results and certifications will then be compared to the required specifications and a determination will be made as to the final use or disposition of the item. It should be noted that testing and verification for performance within proper operating parameters will occur multiple times throughout the construction process as was the case during past detector construction projects. This multi-tiered testing approach will ensure that improperly installed, faulty, or failed components are detected at the earliest possible opportunity and allow immediate remedial action to be taken without jeopardizing or negatively impacting detector operations.

7.2 IMPLEMENTATION GUIDANCE

The BTeV project approaches QA using the five-step template of Fermilab's integrated safety management framework. The BTeV project's five-step quality process encompasses: Step 1, Defining the work; Step 2: Analyzing potential consequences; Step 3: Developing a work plan with appropriate controls; Step 4: Performing the work; Step 5: Ensuring performance. This template is described in greater detail below, in the form of questions to guide the WBS managers and workers involved, as they plan the work for each WBS Level 2 system. The template captures the ten essential quality program criteria specified in the documents referenced above. Managers, supervisors, and workers are each responsible and accountable for the quality and safety of the work they perform and the work that is performed under their purview. The BTeV QA/Procurement (QAP) Coordinator makes QA expertise and tools available to WBS managers and workers and provides internal oversight of QA implementation on the project. The BTeV Project is subject to additional QA oversight by the BTeV Project Director, the Deputy Laboratory Director, the Laboratory Director, the DOE Federal Project Director for BTeV, the Acquisition Executive, and regulators.

7.3.1 Define the work

- What is the scope, goal or deliverable?
- What quality is required to achieve the intended purpose?
- What plans, processes, or records are necessary to satisfy the technical requirements, or ensure an effective interface with other systems ?

7.3.2 Analyze the potential consequences

- What must go right, in order to succeed?
- What can go wrong? How serious a problem would this be?
- What are the worst credible ill consequences for worker health or safety, public health, the opinion of Fermilab held by its neighbors, the environment, cost, mission accomplishment, scientific reputation, security, and schedule?

7.3.3 Develop a work plan with appropriate controls

- What knowledge, training, or qualifications will enable workers to achieve success?
- How will quality be built into the work effort?

- How will problems be detected and corrected at the earliest time and prevented from recurring?
- What documentation is necessary? How will it be prepared, reviewed, approved, revised, distributed, and used to ensure success? Who will do this?

7.3.4 Perform the work

- How will work be performed correctly the first and every time, including compliance with applicable regulations, requirements, and standards; proper use, maintenance, and calibration of tools; and assurance that materials and other items are satisfactory for the intended use?
- How will the design be known to be adequate for the purpose, including the selection and implementation of appropriate standards and scientific/engineering principles, and the definition and control of interfaces?
- How will reliability, availability, maintainability and inspectability (RAMI) be factored into the design?
- How will the design be verified prior to implementation?
- How will it be assured that procured items will arrive on time and perform as expected, including supplier qualification and performance?
- How will items be accepted, including acceptance criteria, acceptance tests, and the calibration/maintenance of inspection/test equipment?
- How will interfaces (physical, temporal, electric, electronic, signal, facility, interpersonal, inter-organizational, etc.) be managed to assure success?
- What documentation (as-built drawings, operator manuals, training manuals, certifications, travelers, test reports, etc) must be prepared while the work is being done, to ensure it is done correctly or to provide to the user when the item is complete?

7.3.5 Ensure performance

- How will we know and document that the work was done correctly?
- If something goes wrong, how will we understand what happened, recover, and learn from it?
- How will we know that personnel, systems, and procedures continue to be satisfactory to assure the quality of future work?
- What oversight will be provided and by whom?

Documents that are critical to the safe and successful accomplishment of a WBS Level 4 system or its operation are controlled documents. Documents control will be implemented using the BTeV Document Control System. The WBS manager will obtain a BTeV document number from the BTeV Document database, ideally when the document starts to be drafted. The controlled documents necessary for performing the work must be maintained carefully by the WBS manager and the master copy must be delivered to the BTeV Project Manager at the completion of the work for archiving. Daily backups are performed on the BTeV Document System.

8. RISK MANAGEMENT

The BTeV Risk Management Plan (RMP) provides a structured and integrated process for identifying, evaluating, tracking, abating, and managing project risks in terms of three risk categories: cost, schedule and technical performance. The following is a summary of key aspects of the RMP. A general discussion of risk may be found in Section 7 of the Acquisition Strategy Plan for the BTeV Project (ASP).

Any project faces both threats and opportunities and must strive to exploit the opportunities while ensuring that the threats do not derail the project. Numerous informal and formal approaches are used for identifying threats and opportunities, assessing their likelihood, prioritizing them for possible mitigation or exploitation, and devising strategies to do so. The key to successful risk management is alertness to potential risks and a deliberate approach to accepting, preventing, mitigating, or avoiding them. The BTeV project becomes aware of potential risks in many ways, notably during work planning, meetings, reviews, and via lessons learned from others. Routine meetings, such as weekly Technical Board meetings, routine WBS Level 2 system meetings, and monthly progress meetings, provide important forums for identifying, discussing, and resolving key risk areas and developing and adopting mitigation plans. Risk has been managed during the planning and design phase by implementing appropriate actions, such as ensuring adequate contingency and schedule float, pursuing multiple parallel approaches, and/or developing backup options. Detector construction projects are well within the experience and expertise of the BTeV collaboration. Every effort has been made to specify these projects in a manner that reduces the risk to an acceptably low level.

The technical risks facing the BTeV Project are no greater than those facing other HEP projects, and as in them, risks that are identified will be managed as early as possible to assure that they do not derail the timely completion of the project or stress its budget in unexpected ways. The initial risk assessment indicates the project will have low cost, schedule, and technical risk exposure, with the exception of the Pixel Detector and EMCAL, which were assessed to have a moderate risk level. Another source of moderate risk affects schedule, and it is due to potential delays in the appropriation and release of project funding.

8.1 RISK MANAGEMENT RESPONSIBILITIES

The BTeV Project Director has delegated the responsibility for overall project risk management to the BTeV Project Manager. The Project Director is responsible for approving the risk management approach and providing oversight for the BTeV risk identification and mitigation process. The BTeV Project Manager develops the Risk Management approach including a Risk Management Board (RMP) that he/she chairs. The composition and purpose of the RMB are described in the RMP. The BTeV Quality Assurance Program Coordinator functions as a Risk Management Coordinator to help the Project Manager carry out his/her responsibilities in this area.

Because contingency is one of the major resources available to deal with problems arising during project execution, the management of cost, schedule and technical risks and the management of contingency are closely linked. Proactive risk identification and mitigation can therefore reduce pressure on contingency, by reducing the probability of unpleasant surprises that could require contingency to resolve.

8.2 RISK MANAGEMENT PROCESS

The Risk Management Process consists of a five step process: 1) identifying potential project risk, 2) analyzing project risk, 3) planning risk abatement strategies 4) executing risk abatement strategies, and 5) monitoring the results of and revising risk abatement strategies.

8.3 TECHNICAL RISK

Preparation of clear and concise specifications, judicious determination of subcontractor responsibility and approval of proposed lower tier sub-subcontractors, and implementation of QA provisions will minimize technical risk. Projects have been designed to further minimize technical risk by exploiting previous experience to the greatest extent possible, and minimizing exposure to single vendor failures.

Making deliberately conservative design choices, where possible, and carrying out extensive detector R&D where new technologies are involved has minimized technical risk throughout the BTeV Detector Project. Use of single sided sensors for the forward microstrip tracker, extensive R&D on the silicon pixel detector and the RICH readout, use of a switch based on commercial off-the-shelf components in the data acquisition system, reduction in component variety, and common integrated circuit technologies wherever possible will reduce risk. In all cases, the expertise of personnel involved in the design and implementation of previous versions of BTeV systems have been exploited to the fullest possible extent. Moreover, institutional commitments have been carefully crafted within the subprojects in order to help ensure timely and successful completion of the Project.

8.4 COST RISK

Use of fixed-price subcontracts and competition will be maximized to reduce cost risk.

8.5 SCHEDULE RISK

As outlined in Section 7.3 of the ASP, schedule risk will be minimized via:

- Aggressive R&D, including bench testing and beam testing
- Realistic planning,
- Verification of subcontractor's credit and capacity during evaluation,
- Close surveillance of subcontractor performance,
- Advance expediting, and
- Incremental awards to multiple subcontractors when necessary to assure total quantity or required delivery.

Incentive subcontracts, such as fixed-price with incentive, will be considered when a reasonably firm basis for pricing does not exist or the nature of the requirement is such that the subcontractor's assumption of a degree of cost risk will provide a positive profit incentive for effective cost and/or schedule control and performance.

In addition, the Project will be tracked monthly, with schedule changes carefully monitored and approved through a change control process overseen by a combination of the Project Manager, the Laboratory Directorate, and DOE (see section 8 of this document).

8.6 RISK ANALSYIS

BTeV project risks are analyzed by considering their likelihood or probability of occurring together with the consequence to the project's technical performance, cost, and/or schedule baselines. Probability is assessed qualitatively as **unlikely**, **likely**, and **very likely**.

Consequence relates to the potential impact of the threat on cost, schedule, and/or the technical baselines. Each threat will be evaluated on these three aspects using the criteria and thresholds in Table 1. The highest (worst) consequence determines the overall consequence rating for the threat.

Table 1: Consequence Assessment Matrix

Consequence / Risk Area	Low	Moderate	Critical
Cost: Worst likely impact:	≤ $25K	≤$200K	>$200K
Schedule: Worst likely impact:	< 1 week delay of critical path or major milestone	Delays major milestone or critical path by <1 month	Delays major milestone or critical path by >1 month
Technical: Worst likely impact on scope or performance:	Negligible, if any, degradation	Significant technical/scope degradation	Baseline scope will not be achieved.

Based on the combination of probability and consequence, risks are classified as high, moderate or low in accordance with the categorization provided in Table 2. Probability percentages in Table 2 are meant as qualitative guides, not as absolute thresholds.

Table 2: Risk Classification Matrix

	Consequence		
Probability	**Low**	**Moderate**	**Critical**
Very Likely (p > 80%)	Moderate	Moderate	High
Likely (20% < p < 80%)	Low	Moderate	High
Unlikely (p < 20%)	Low	Low	Moderate

8.7 RISK MANAGEMENT TOOLS AND PROCESS

Risk management is a line activity in BTeV and, as such, will be a normal part of many activities and meetings. The BTeV Project Management meetings will take up risk issues from time to time. The

BTeV Technical Board, which meets weekly, will also regularly include reports from Level 2 managers that will address risk-related issues. Level 2 subproject managers will be responsible for maintaining their project risk data in the same Open Plan® Database that they use for scheduling. A "watchlist" will be generated from this database to assist the Project Manager in carrying out his activities.

9. FUNDS MANAGEMENT

Funds will be made available by the Director to the Project on an annual basis following the receipt of the Initial Financial Plan from DOE. These funds will correspond to a financial plan and a funding profile to project completion as determined by the Director. The funding profile will include contingency in each year of the project. Actual expenditures and commitments on the BTeV Project are limited by the cumulative amount of funds authorized by DOE for the BTeV. At no time shall the cost incurred plus the outstanding commitment balance on each of the subprojects exceed the funding level authorized or granted by the sponsor.

Work packages will be established by the Fermilab Budget Office following the WBS structure. The accumulation of M&S costs in these accounts will be initiated through purchase requisitions originating with the engineering and scientific staff assigned to the various subsystems. Signature authority levels will be provided to the Fermilab Business Services Section by the Project Director to assure that only authorized work is initiated.

10. BASELINE CHANGE CONTROL

The BTeV project's performance measurement baselines must be managed after CD-2 in a manner that ensures that they are not modified without appropriate approval. In reality, changes are likely during a project's life, so any project requires a system for managing, controlling, and rejecting or implementing them. Thus, the BTeV's project management systems include a mechanism, described in this section, for proposing, evaluating, reviewing, approving, documenting, and communicating baseline changes. This process includes a hierarchy of change officials with clear approval levels, and a method for receiving, reviewing, and disposition of proposed changes.

10.1 CHANGE CONTROL AUTHORITIES AND LEVELS

The BTeV project baseline change control levels are defined in a hierarchical manner that provides change control authority at the appropriate management level. DOE 413.3 assigns the authority to approve changes of such magnitude that they constitute baseline "Deviations" to the Secretarial Acquisition Executive. Deviations include new technical scope or performance not in conformance with the approved Congressional budget, cumulative schedule delays of 6 months or more in a Level 1 milestone, and increases to the TEC that would exceed 25% ($46M for the BTeV's TEC of $186 million). Level 1 changes must be approved by the Acquisition Executive for each subproject. Level 2 changes will be approved by the DOE BTeV Project Manager, and Level 3 changes must be approved by the FNAL Deputy Director. Level 4 changes are within the purview of the BTeV Project Manager, and Level 5 changes can be approved by the appropriate WBS manager. Change control authorities

and thresholds are listed in Tables 10.1a and 10.1b. Any Level 1-3 changes will be reviewed by the BTeV PMG with members from the Integrated Project Team (IPT) before approval.

Table 10.1a - Summary of Baseline Change Control Thresholds For the BTeV Project, Levels 0-2

	Secretarial Acquisition Executive (Level 0)	Acquisition Executive (Level 1)	DOE BTeV Project Director (Level 2)
Technical	Any change in scope and/or performance that affects mission need requirements.	Addition or deletion of major subsystem..	
Schedule	6 month or greater increase (cumulative) in the original project completion date.	Any change to level 1 milestones.	Any change to level 2 milestones (see PMP).
Cost	Increase in excess of $25M or 25% (cumulative) of the original cost baseline.	Any increase in Total Project Cost and/or increase in Total Estimated Cost.	Any use of contingency that would take the contingency as percentage of TEC ETC below 28%.

Table 10.1b - Summary of Baseline Change Control Thresholds For the BTeV Project, Levels 3-5

	Fermilab Deputy Director (Level 3)	BTeV Project Manager (Level 4)	Subproject Manager (Level 5)
Technical	Major technical changes that are significant departures from the technical baseline. Changes that affect ES&H requirements or impact accelerator systems. Out-of-scope changes to upgrade physics capabilities.	Related technical changes to multiple subprojects that do not diminish performance .	Minor technical changes to a single subproject that do not diminish performance.
Schedule	Any change that results in the delay of a Level 3 Director's milestone.	Any change that results in the delay of a Level 4 milestone by more than one month.	Any change that results in the delay of a Level 5 milestone by more than one month
Cost	Increase in the cost of a single item by more than $100K. Increase in the Project base cost exceeding $0.25M during the previous 12 months.	Increase in the cost of a single item by more than $10K. Increase in a subsystem base cost exceeding 10% during the previous 12 months.	Increase in the cost of a single item by less than $10K.

10.2 BASELINE CHANGE CONTROL PROCESS

A change may be proposed by any project participant or stakeholder. If the appropriate WBS manager, the BTeV Project Manager, the BTeV Project Director, or a representative of the funding agency is not the change advocate then the change advocate must find a co-sponsor from among them. The change advocate must complete the standard BTeV Project Change Request (PCR) form (see Appendix A), which will be available electronically in the BTeV Project Document database. Upon submission, the Project Manager assigns a change-request number, enters the proposed change into the PCR Log, and sends it simultaneously to the appropriate WBS manager(s). In addition, an accompanying Technical, Cost, Schedule, Safety Assessment (TCSSA) form (see Appendix A) is completed. The Project Manager reviews the assignment of change level, reviews the identification of affected system(s), confers with the Project Director, if needed, and changes them, if appropriate. Then the TCSSA is routed in parallel to the appropriate experts who will estimate the cost, schedule, technical, and safety impacts of the proposed change. The change advocate or anyone else involved may call meetings to understand, engineer, or further develop the PCR so that the impacts can be estimated accurately, and the TCSSA can be completed.

Each change authority at Level 4 and above will chair a change control board (CCB) to provide review and advice. The Level 4 CCB is chaired by the BTeV Project Manager. Other members are the Project Director, the experiment spokesperson, a subset of Level 2 managers, and representatives of the impacted Fermilab Divisions, where appropriate. After Level 4 CCB review and PM approval, Level 3 or higher PCR's are routed to the Project Director for approval and forwarding to the Level 3 CCB. The Project Director acts as advocate for Level 3 and higher change requests. The FNAL Deputy Director chairs the Level 3 CCB, which includes as members the Project Director, Project Manager, any WBS manager potentially affected by the proposed change, and an appropriate representative of the scientific program planned for BTeV. The ES&H Coordinator, QA Coordinator, and Project Manager are *ex officio* advisors to the Level 3 and Level 4 CCBs, with the Project Manager serving as executive secretary to both the boards. At the discretion of the BTeV Director, Level 3 and Level 4 review can be combined into one step for Level 1 and Level 2 change requests. Level 1 and 2 change proposals must be approved at Level 3 before being transmitted forward to the DOE Federal Project Director for BTeV (Level 2). In general, change proposals must be approved by lower level change boards and officials (starting at Level 3 or 4), before being transmitted to the next higher level for review and action.

Project Change Requests (PCR) must be approved at the appropriate level and documented before any baseline will be modified. The review and action by any CCB can include increasing the Level of the PCR, so that it must go to a higher level for approval.

When the PCR is approved by the appropriate level change official, it becomes a Change Order, and is transmitted to the Project Manager, who will update the Change Log, ensure the baselines are modified appropriately, and communicate the action to all project participants.

10.3 IMPORTANT FEATURES OF THE CHANGE CONTROL SYSTEM

To keep the project moving, it is expected that action will be taken on Project Change Requests within two weeks at each level, more rapidly if at all possible. Fermilab's BTeV Project Manager will communicate any approved Level 3 (and lower) changes to the DOE BTeV Federal Project Director on at routine basis.

Significant changes to the technical equipment scope of WBS 1.0 and 2.0 will involve consultation with the BTeV Collaboration. Significant changes to the BTeV scientific capability goals and user interface will involve similar consultation.

Technical and other details of the change may evolve during its processing and impact analysis. With the agreement of the change advocate and affected WBS manager(s), it is acceptable to modify the PCR to reflect this evolution, rather than formally withdrawing and replacing it.

It is not required that cost overruns, underruns, minor changes in schedule plans or inadvertent delays be reflected in the performance measurement baseline. These phenomena occur during all projects, and they can be tracked as variances. Changes to technical deliverables or specifications that are not consistent with the approved technical baseline must be approved via the change-control process. Changes to technical approach (how the deliverable will be provided) do not need to be documented via a PCR, unless the proposed change significantly increases risks to project success.

Directed changes can be initiated at the Secretarial level, Level 1, or Level 2. Directed changes will be communicated to the BTeV DOE Project manager, Project Director and Project Manager, who will prepare a Project Change Request and initiate the TCSSA analysis. The completed TCSSA analysis will be submitted through intermediate Change Levels (for information, not action) directly to the official directing the change. Upon approval, the baselines will be modified to reflect the scope, cost, and schedule impacts of the directed change.

WBS managers may at any time prepare and submit PCRs that provide more detail and specificity within the approved technical, cost, and schedule baselines. For example, at the time a contract is awarded and the vendor's work plan and specific progress payment schedule is known, the WBS manager could submit a PCR to change the BCWS to reflect the current work plan and schedule. PCRs of this type are Level 5 changes, so long as they do not increase the estimated cost, delay the final deliverable beyond its baseline date, or reduce the technical performance provided. Such a PCR would simply be logged in, reviewed by the Project Manager to verify that it has no impacts outside the approved baseline, immediately approved, incorporated formally into the baseline, and communicated to project participants. It is not acceptable to implement PCRs of this type for work packages that are already well underway or to reschedule work that had milestones or deliverables prior to the submission date of the PCR.

10.4 CHANGE CONTROL RESPONSIBILITY

The Project Manager is responsible for executing and documenting the approved technical scope for the overall project within the approved cost and schedule baselines. Each WBS manager is responsible for executing and documenting the approved technical scope of the WBS system, within the approved cost and schedule baselines. The Project Manager and WBS managers must use the change control process to add, subtract, or modify the approved technical baseline scope/deliverables. In addition, they must fulfill the duties described above regarding analyzing the impact of PCRs and they must

serve on CCBs. The Project Director serves as the advocate for Level 3 and higher PCR's at the level 3 CCB and beyond.

The Project Manager is responsible for the administrative operation and coordination of the overall baseline change control system in support of all BTeV Project participants. This responsibility includes initial review and administrative processing of all BTeV PCRs. This begins upon receipt of a draft PCR from the change advocate and continues through the impact analysis, through the various CCB reviews, to the disposition of the PCR and communication of the result. The Project Manager is responsible for implementing approved technical, cost/budget, and schedule/milestone baseline changes in the official BTeV project baseline documents and files.

APPENDIX A: CHANGE CONTROL FORMS

Figure A-1 BTeV Project Change Request Form

PCR No: **Date:**
(Assigned by PM)
PCR Title:
Originator: **Co-Sponsor:**
Change Type: ☐**Technical** ☐**Schedule** ☐**Cost**

WBS No:

Change Description:

DOE Directed Change:	☐ **YES**	☐ **NO**
Urgent:	☐ **YES**	☐ **NO**
DOE Approval	☐ **Required**	☐ **Not Required**
If urgent, please explain		

Level of Change
☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

CCB Review done:	☐ **Level 3**	☐ **Level 4**

Disposition:	
L3 Manager approved: ☐Yes ☐No Signature/date:	L2 Manager approved: ☐Yes ☐No Signature/date:
PM approved: ☐Yes ☐No Signature/date:	Other approval: ☐Yes ☐No Signature/date:

Project Director: ☐ Approved ☐Disapproved	Signature/Date:
FNAL Director: ☐ Approved ☐Disapproved	Signature/Date:
DOE BTeV Project Director: ☐ Approved ☐Disapproved	Signature/Date:

PCR Disposition:	
☐**Accepted**	☐**Not Accepted**
Implementation Date:	

Figure A-2 BTeV Technical, Cost, Schedule, Safety Analysis Form

BTeV Technical, Cost, Schedule, Safety assessment Form (TCSSA)

PCR No:
(Assigned by PM)

Date: 01/01/2004

PCR Title:

WBS No:

Change Description:

Technical Impact:

Cost Estimate of Change:
Total Cost of WBS element:

New Cost Estimate by Fiscal Year($K)

FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010

Cost Change by fiscal Year($K)

FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010

Schedule Change:
Milestones Impacted:

Total Schedule Change:

Safety and/or Environmental Impact of Change:

Effect if NOT Approved:

PM Approved: ☐ **Sig/Date:**	**L2 Approved:** ☐ **Sig/Date:**	**QA Approved:** ☐ **Sig/Date:**	**ESH Approved:** ☐ **Sig/Date:**

BTeV TCSSA Form Version 1.0
July 16, 2004

Figure A-3 BTeV PCR Flow

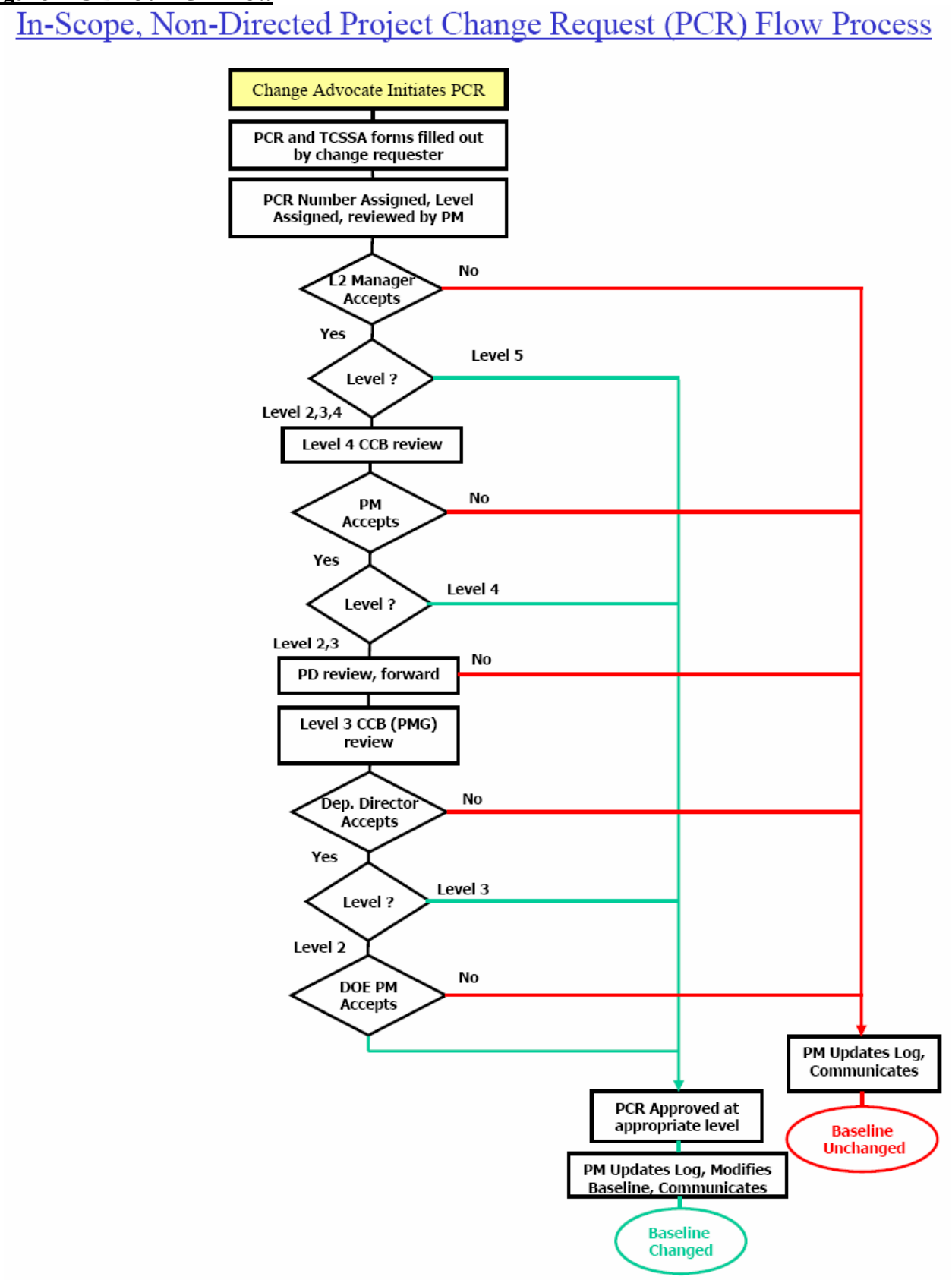
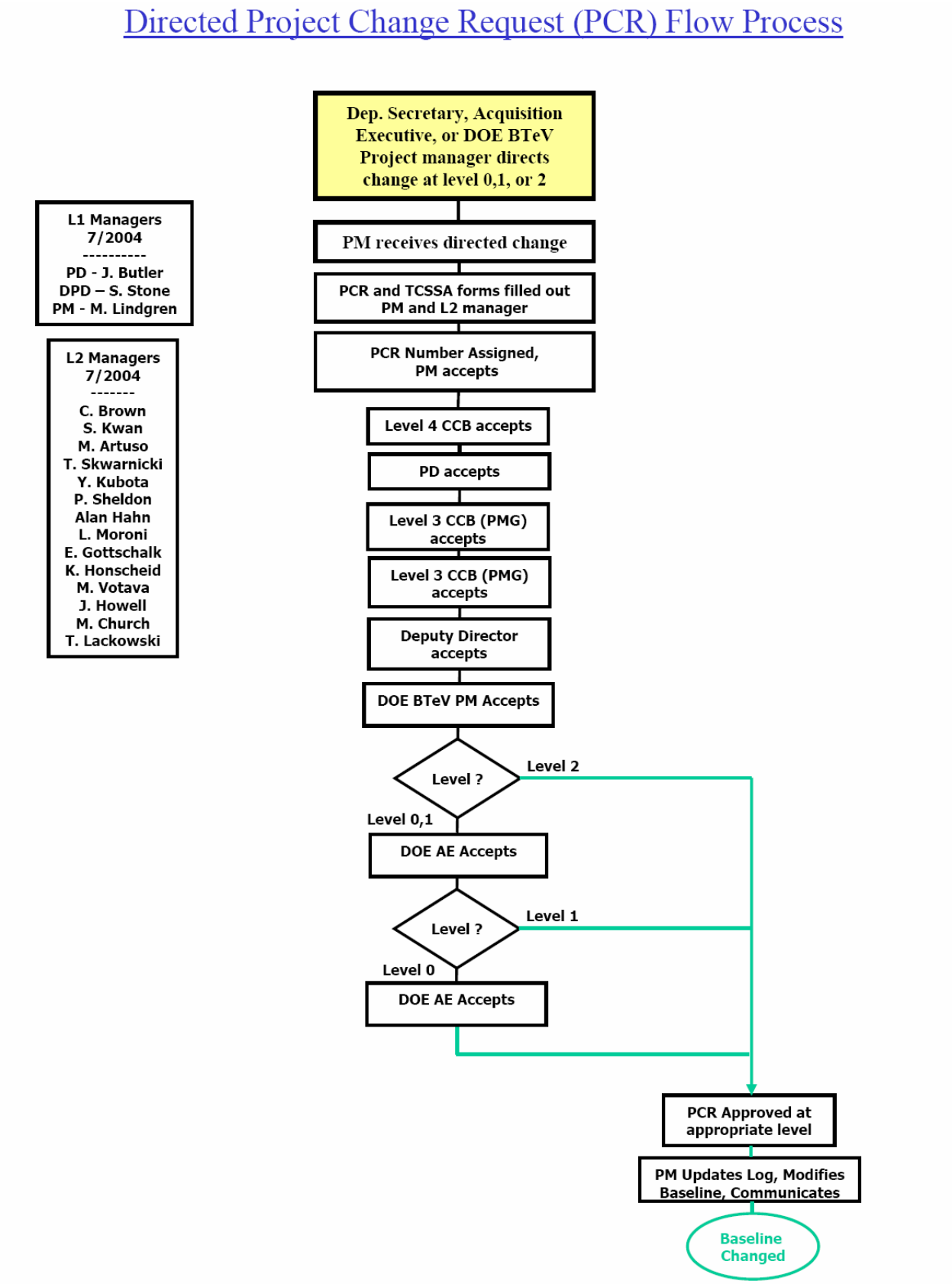


Figure A-4 BTeV Directed PCR flow



APPENDIX B: OVERHEAD POLICY

INDIRECT BURDEN ALLOCATION METHODOLOGY

I. General Policy

It is the policy of the Laboratory to allocate indirect expenses (Material/Service Acquisition, Common Site Support, and General and Administrative Expenses) to all final cost objectives. All costs incurred are subject to the indirect burden allocation including the total cost of goods and services procured through Fermilab by user institutions or other non-Lab entities. This policy is consistent with the requirements of our Prime Contract with DOE to comply with Cost Accounting Standards, as well as the requirements in D.O.E. Order 2110.1A, "Pricing of Departmental Materials and Services".

The Budget Office and the Accounting Department develop provisional indirect burden rates jointly. Normally they will be based upon the Laboratory's current year budget. However, in the case where the approved budget for the upcoming year has not been released, or in the case of a new methodology with which the Lab has little or no experience, the rates may be based on prior year(s) actual rates.

The provisional rates will go into effect each October 1st, with a retroactive adjustment to actual (variance distribution) at least annually at September 30. Major changes in funding, budgetary allocations, or the Lab's indirect burden allocation methodology could necessitate a rate change (increase or decrease) and/or a variance distribution during the year; such rate changes and variance distributions are subject to Director's office approval. The Accounting Department performs a monthly analysis of the Indirect Burden Allocation and monitors the accumulated variances.

II. Exceptions

Although the indirect burden allocation rates are generally applied to all final cost objectives, the Laboratory currently has provided for exceptions to that policy as stated below:

A. When Laboratory personnel provide a service (labor cost) while away from the Laboratory for an extended period of time (defined as greater than 180 days), the Common Site Support rate will not be charged upon request of applicable Division/Section management.

B. When special conditions or extenuating circumstances exist, the amount or applicability of the indirect charge may be negotiated with the Director. When an adjustment is granted, said adjustment should be included in the "Agreement for an Experiment", Memorandum of Understanding, or other formal document as appropriate, and such document should be provided to the Accounting Department before charges are incurred. If costs billed to a user institution will not include indirect charges, those charges must be transferred to a valid Laboratory B&R code. The transfer is completed as part of the month-end burdening process where indirect costs are mirrored to the appropriate lab code.

C. Pass Through Orders are only charged a 1.5% G&A rate. (Link to separate section on this website that explains this exception to the indirect allocation.)

D. Large Cap Purchase Orders (>$500,000) are charged indirect only on the first $500,000 of purchases. (Link to separate section on this website that explains this exception to the indirect allocation.)

E. Miscellaneous Burden Transactions: There are agreements with the laboratory where the government has imposed restricted indirect rates (i.e. 15% or less) and/or burden exempt tasks.

III. Indirect Burden Rate Calculation

The rates for the provisional Material/Service Acquisition (MSA), Common Site Support (CSS), and General and Administrative (G&A) burden allocations will be based on the following formulas, where the numerator is the pool, and the denominator is the distribution base of the pool:

A. MSA Burden Allocation

The Material/Service Acquisition (MSA) burden pool represents the cost of purchasing services and materials. This includes a range of costs, from the cost of negotiation/creating a contract to the cost of physically processing an invoice.

B&R Code: EC-01-01-040
Expenditure Type: MSA Burden Allocation

Pool – The MSA pool consists of all the costs from the following departments:

Accounts Payables
Inventory Variances
Purchasing
Shipping/Receiving
Stock Room

Base – The MSA burden allocation will be applied to the following expenditure types unless they are on a "special" task (with a Restricted / Exempt burden schedule) or a MSA task (i.e. Have a service type of OP-BURDEN-MSA):

Civil Construction	Material Purchases
Computer Maintenance	Office Machine Maintenance
Computers, Desktop	Procard Purchases
Computers, Hardware Maintenance	Purchased Services
Computers, Software Licenses	Spare parts/Other Issues
Computers. Software Maintenance	Special Process Spares Issues
Demurrage/Container Rental	Stores Issues
Equipment	Sub Contract Services
Equipment Rental	T& M Rigging Services
Fabrication Procurement	T&M Construction Services
Facility Rental	T&M Electrical Services
Freight	T&M Pipe Fitters
Gases/ Cryogenic Fluids	Telephone Expense
Honoraria	Telephone Expense Distribution
Insurance Premium	Temporary Help

B. CSS Burden Allocation

The Common Site Support (CSS) burden represents the cost of running the physical facility and infrastructure (power, property costs, telecommunications, mail service, etc.).

B&R Code: EC-01-01-050
Expenditure Type: CSS Burden Allocation

Pool – The CSS pool consists of costs from the following departments:

Site Power
ES&H Section (All)
Facilities Engineering Services Section (All)
Variances from the Service Centers of the Technical Division
A portion of the Laboratory Services Section including:
- Audio-Visual/Duplicating/Photo Services
- Cafeteria
- Housing
- Library Services
- Users & Travel Offices

A portion of Business Services Section including:
- Mail Operations
- Property Management
- Telecommunications
- Vehicle Maintenance

Base – The CSS burden allocation will be applied to the following expenditure types unless they are on a "special" task (with a Restricted / Exempt burden schedule) or a MSA or CSS task (i.e. Have a service type of OP-BURDEN-MSA or OP-BURDEN-CSS):

Accounting Transfers –Labor	Special Compensation
Construction Engineering	Summer/Temp Emp. Monthly
EOM Wage Accrual – Weekly	Summer/Temp Emp. Weekly
Fringe - Special	Time Worked – Monthly
Machine Shop	Time Worked – Weekly
Service Organization Distribution	Overtime

The base also includes the Vacation, OPTO and Fringe burdens calculated on the expenditure types (i.e. Time Worked – Monthly) that receive it.

C. G & A Burden Allocation

The General and Administrative (G & A) burden represents all the remaining (i.e. Not included within the CSS or MSA burden) indirect costs of running the laboratory.
B&R Code: EC-01-01-060
Expenditure Type: G&A Burden Allocation

Pool – The G & A pool consists of all the costs from the following departments

Directorate (excluding Site Power)
Lab Services Section (The portion not included within the CSS Pool)
Computing Division (The portion assigned to general operating support)
Business Services Section (The portion not included within the CSS or MSA pools)
Legal Office

Base – The G & A base includes the CSS, MSA, Vacation & OPTO and Fringe burden amounts calculated by the applicable burden rates. The base also includes all expenditure types listed within the MSA & CSS sections of this document. Additionally, the base includes the following expenditure types:

Accounting Transfers	Proceeds from Personal Property Sales
Consultants	Recruitment
Computer Services Dist.	Relocation
Donated Funds	Relocation - Temporary
Duplicating Services	Special Events
Educational Expense	Stipend Education
Fees	Stores & Spares loss / OBS
Housing Costs	Training
On-Site Travel Reimbursement	Travel, Domestic, Non Employee
Other Costs and Credits	Travel, Domestic, Lab Employee
Other Utilities	Travel, Foreign, Non Employee
Photo/Film Processing	Travel, Foreign, Lab Employee
Photo/Graphic Services	Vehicle Maintenance
Physical Inventory Adj	Video/Streaming
Postage and related Costs	Visitor Subsistence < 1 year

The base excludes any costs related to charges on tasks with service types of: OP-BURDEN-CSS, OP-BURDEN-MSA or OP-BURDEN-G&A. Additionally, tasks that have "special" burden arrangements (Exempt or Flat Rate) will be excluded from the base.

D. Pass-through Policy

On October 1, 1997 the Laboratory implemented a DOE approved policy that provides for the application of a reduced indirect burden rate of 1.5% to costs associated with procurements qualifying as 'pass-through'. In general, the funds used for pass-through procurements are initially part of the Laboratory's Approved Financial Plan and subsequently transferred to some other institution, organization or individual for the purpose of purchasing and/or developing some item that will further the Fermilab mission. This policy is in compliance with Cost Accounting Standards (CAS) that allow the use of special allocation measures under special conditions.

In order to qualify for the pass-through indirect burden rate the procurement action must be the result of an agreement for services and/or product in excess of $100,000. Typically these agreements will be in the form of a research and development subcontract, an interoffice work order (IWO), or a memorandum purchase order with clearly and precisely defined milestones. Additionally, the individual agreements may be a part of an overarching Memorandum of Understanding (MOU) that must be considered for meeting the minimum $100,000 threshold. All such agreements require the approval of either the Laboratory Director or Deputy Director prior to the initiation of the desired work.

Each request for pass-through action must also have the approval of the Associate Director for Administration. All purchase requisitions representing approved pass-through actions must be recorded in ORACLE Projects against expenditure type, Subcontract Services Pass-Thru, or the exempt Pass-Thru expenditure type as discussed below. The electronic requisitioning system will then automatically route them for approval by the Associate Director for Administration.

In as much as the pass-through rate is part of the Laboratory's overall indirect burden rate structure, application of the pass-through rate is subject to the $500,000 ceiling like any other large cap order. Purchase requisitions representing a pass-through action in excess of $500,000 should be recorded in ORACLE Projects against the exempt expenditure type, Exempt - Subcontract Services Pass-Thru, instead of expenditure type, Subcontract Services Pass-Thru. The electronic requisitioning system will then automatically route them for approval by the Associate Director for Administration.

APPENDIX C: CONTINGENCY MANAGEMENT TOOLS

A risk-based contingency assessment was performed for each WBS 4th-level element, on a component-by-component basis. This analysis was used as part of the evaluation of the cost contingency for the BTeV project. Note however that project contingency will be managed centrally and is not pre-allocated or pre-assigned to any item. All relevant risk areas in the Risk Management Plan were considered, including facilities, design, hardware technology, manufacturing, and supplier capabilities.

C.1 CONTINGENCY ANALYSIS FOR WBS 1.0 AND 2.0

The major risk areas identified for WBS 1.0 and 2.0 are the complexity in the design and fabrication, and the competitiveness of the vendors. Higher risk is associated with a greater degree of customization in the design, and when an item is fabricated upon order rather than being a standard, stocked 'catalog' item. Higher risk is associated with having fewer qualified vendors. It was found that all components in WBS 1.0 and 2.0 could be classified into categories based on the maturity and complexity of design and the number and type of suppliers . In the case of labor, risk depends on the degree of experience with the project or similar projects. The descriptions of these categories and suggested contingency ranges, taken from BTeV Document #2471, are listed below.

M&S Contingency Categories and Ranges:

1) 0% on items that have been completed
2) 10-15% on items that have already been purchased at least once (perhaps in small quantities) or items for which there is a very firm quote and for which there is more than one potential vendor.
3) 25-50% on items that have already been purchased at least once (perhaps in small quantities) or items for which there is a very firm quote but for which there is likely to be only one vendor. This we try to avoid.
4) 25-50% on items that can be readily estimated from a reasonably detailed design or for which there exists a very close "analogous system", with well understood costs
5) 50-70% on items for which only a conceptual design exists. We think we are past this for most projects
6) 50-70% for items which have unproven yields or for which there are unique issues (e.g. an uncertain cost and a single vendor)
7) 70-100% for which there does not yet exist a detailed conceptual design (few, if any, of these)
8) 30-70% for an item whose scope could increase due to unforeseen backgrounds or operational conditions
9) Variable %: uncertainties due technology projections. Have to do this on a case by case basis, comparing best, worst projections

Labor Contingency Categories and Ranges

1) 15-25% for a project which has been done before and has a reasonably good estimate based on actual time paid for
2) For a project which is well-defined and effort has been quantified, 25% if there is no paid idle time or 50% if there is

3) 30-40% for a project with only a time and motion type study derived from a limited-scale test
4) For a complex project with a long learning curve, that % of additional labor that the project can absorb efficiently. For software development, we set this at 25%
5) 50% for a project of uncertain labor requirements

Additional unusual risks have been identified by BTeV Level 2 managers. In determining overall contingency, these risks must be taken into account as well. BTeV Document 2471 explains how this is to be done.

The values in this table are consistent with guidelines in DOE G 430.1-1, Chapter 11 Contingency, for Construction Projects, special facilities and equipment procurement, for this stage of the project.

C.2 CONTINGENCY ASSESSMENT FOR WBS 3.0

The major risk areas identified for WBS 3.0 are the potential for vendor price escalations, and equipment technical complexity. Vendor price escalation risk in this project primarily comes from local area economic improvement in the construction trades. Equipment technical complexity includes the degree of customization, sophistication and uniqueness of equipment, and the amount of BTeV specification work required.
It was found that all components in WBS 3.0 could be classified into risk categories based on the two criteria identified above, the equipment technical complexity, and the vendor risk. The descriptions of these categories are listed below.
Equipment Technical Complexity:

1. Very Low: Commercial catalog item, specs/design provided by supplier, stocked (fabricated before order).
2. Low: "Standard" equipment with established design; specs provided by BTeV.
3. Moderate: "Standard" equipment with customized design; specs/design provided by BTeV.
4. High: Equipment designed in-house; specs/design provided by BTeV, assembled from components by BTeV.

Vendor Risk:
A. Low: Several effectively equivalent suppliers
B. Moderate: Few equivalent suppliers
C. High: Only one or two foreign suppliers, significant vendor "monopoly"

Contingency amounts were determined for each 4th-level WBS component by assigning it a risk level based on the above two categories, and then determining the appropriate contingency from the Table D-2. The values in this table are consistent with guidelines in DOE G 430.1-1, Chapter 11 Contingency, for Construction Projects, special facilities and equipment procurement, for this stage of the project.

Table C-1: Contingency Analysis Matrix

Contingency as percentage of capital and ED&I		Supplier Type		
		A. Many	B. Two	C. One
Design Type	1. Catalog	5%	10%	15%
	2. Standard	10%	15%	20%

	3. Modified	15%	20%	25%
	4. New	20%	25%	30%